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EXPLOSION OF TWO STEAM-BOILERS AT JEWELL'S MILL, BROOKLYN, N. Y.

IN the SCIENTIFIC AMERICAN of February 25, 1882, was published a short notice of the explosion of two large steam-boilers on February 16, 1882, at the Jewell Flouring Mill, in Brooklyn, N. Y. Further reference was also made to it on March 11. This double explosion caused the death of Levi J. Stevens, the engineer, injury to a number of persons, and the destruction of the boiler-house and portions of the main building and chimney, as shown in Fig. 3.

These boilers were of the horizontal, internally-fired type, known as drop-flue boilers. They were seven feet diameter and twenty-one feet long, shells of iron plates, single riveted, originally called five-sixteenths of an inch thick.

The two exploded boilers had seven courses of plates in the shell, three plates in each course. They were made twenty-one years before the explosion, and worked, as their makers intended, at about thirty pounds per square inch, driving a condensing beam-engine 34"x48", at 56 revolutions per minute, till about twenty months before the explosion, at which time additional power was required, and the pressure was increased to and limited at fifty pounds.

The third boiler, which did not explode, but was thrown about fifty feet out of its bed, was of the same size, but of weaker construction, on account of the larger exit flue in the shell.

A few minutes before noon, on February 16, while the engine was running at the usual speed, the steam-gauge indicating forty-seven pounds pressure, and the water-gauges showing the usual amount of water, and while the engineer was standing immediately in front of the boilers, the middle one exploded; that is, the shell burst open from weakness, and was nearly all stripped off. The remainder of the boiler was thrown high in the air, probably made several somersaults in the air, and brought down beneath it in its fall a corn conveyor which passed above the boiler-house roof and entered the main building about thirty feet above the boiler site. The shaft and worm of this conveyor lay beneath No. 2 boiler, as shown in Fig. 3, proof that the boiler rose higher in the air than the position of the shaft and worm.

During the period of time that this boiler was in the air, No. 1, the left-hand boiler, having been forcibly struck by parts of No. 2, also broke open, but on such a line of initial fracture that its main portion was projected horizontally to the front, arriving at the front wall of the building in time to fall under No. 2, as shown in Fig. 3. There can hardly be a question about the direction taken by these two boilers, or about the position near the top of the initial boiler of the first break in the shell. The most probable hypothesis is indicated in Fig. 4, inasmuch as the line A B separates a ring of plates which was found folded together beneath the pile of *débris*. If the initial break had been at some point on the bottom, then this belt of plates would have been thrown upward and flattened, instead of downward, where it was folded by the flood of water from No. 1 boiler.

The engineer's body was taken from beneath the two boilers, which were piled up as shown in Fig. 3.

The third boiler was hoisted out of its bed by the issuing water, and thrown about fifty feet to the right of its proper place.

These two boilers contained probably more than fourteen tons of water, which had a temperature due to forty-seven pounds pressure, and the effect of its sudden liberation equal that of several hundred pounds of burning gunpowder.

The most reasonable hypothesis is that the middle boiler broke first at the calking edge of the longitudinal seam, A B, Fig. 4, this line having been gradually weakening since the working pressure was increased, and, being covered by brickwork, was undiscovered by the inspector.

Second. That the iron was brittle, although its tensile strength may have been satisfactory—said to have been 45,000 or more. A piece broken off the broken edge, A B, appeared more like zinc than good boiler iron.

Third. That, in view of the scant thickness and poor quality of the iron, fifty pounds was too much pressure, and developed the fatal defect that might never have resulted from a pressure of thirty pounds.

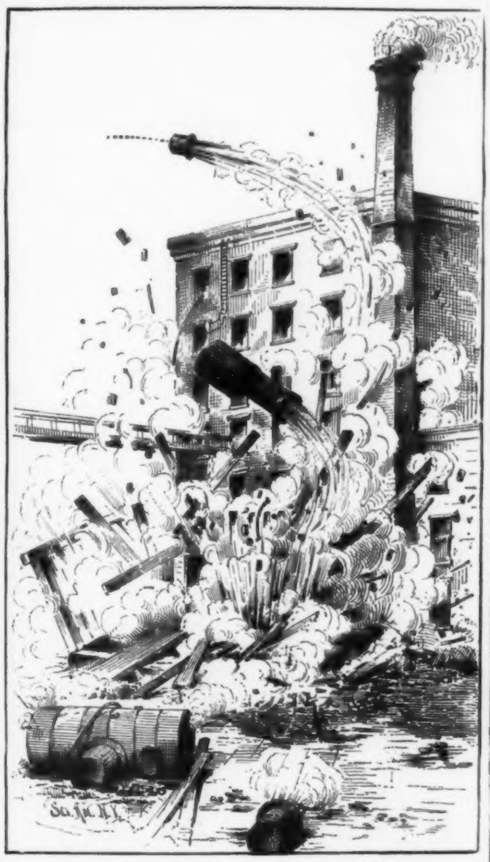


FIG. 2.—EXPLOSION OF BOILERS AT JEWELL'S MILLS, BROOKLYN, N. Y.

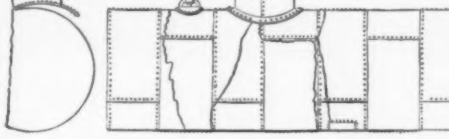


FIG. 4.—SHOWING INITIAL RUPTURE.

In view of these facts, it seems desirable that a simple and the safest practicable rule for determining at what pressure old boilers may be worked should be established by law, and that no person or company should be allowed to run a boiler at a higher pressure than the law would allow.

It is desirable also that the government methods of determining the fitness of boiler iron, which relate not only to its tensile strength, but also to its homogeneousness, toughness, and ability to withstand the effect of repeated heating and cooling, should be enforced under legal enactment in all land boiler practice as well as marine.

"EQUIDISTANT GEAR CUTTERS."

By PROF. C. W. MACCORD, D.S.

THE importance of making cut spur wheels for many purposes interchangeable is becoming more and more clearly recognized. This may be effected in many different ways, but the systems best known and most extensively adopted are the involute and the epicycloidal, to the latter of which we shall at present confine our attention.

Using, as we must use, a constant describing circle, the form of the epicycloidal face changes with the diameter of the pitch circle. Therefore, since the outline of the cutter must be identical with that of the space between two adjacent teeth, it would be necessary to have a separate cutter for every wheel in order to make a perfect set.

This is clearly out of the question; and fortunately the variations in the correct tooth outlines diminish as the size of the wheel increases, so that it is practicable to attain a reasonable degree of exactness with a limited number of cutters. Each cutter serves for several wheels, one of which, whose diameter will be intermediate between the highest and lowest for which the cutter is used, may be exactly correct. And thus the problem is presented to determine the numbers of teeth to which each one of a series of cutters should be made to correspond, in order that the errors may be equally distributed; that is to say, in order that each cutter shall differ in form from the next one in the series by an equal amount.

In relation to this Prof. Willis ("Principles of Mechanism," p. 141) says: "This being the case, it appeared worth while to investigate some rule by which the necessary cutters could be determined for a set of wheels, so as to incur the least possible chance of error. To this effect I calculated, by a method sufficiently accurate for the purpose, the following series of what may be called equidistant values of cutters; that is, a table of cutters, so arranged that the same difference of form exists between any two consecutive numbers."

Again, Mr. Geo. B. Grant writes (*Am. Machinist*, vol. 4, No. 2, p. 6) as follows:

"Without taking considerable space, it can only be stated that the formula which locates the first tooth to be cut by any cutter, is:

$$t = \frac{a\,n}{n - s + \dfrac{a\,s}{z}};$$

in which

a=the initial number, usually 12;

z—the final number, usually infinity for a rack;

n—the number of cutters in a set to cut from a to z.

s=the number in the series, of the particular cutter whose first tooth, t, is desired."

Prof. Willis gives his table with no other explanation than is above quoted; it relates, we should state, to a set of epicycloidal wheels in which the diameter of the describing circle is half that of the wheel of 12 teeth, which therefore has radial flanks; but the addendum, or amount by which the face of the tooth projects beyond the pitch circle is not given. In regard to Mr. Grant's formula (the content also

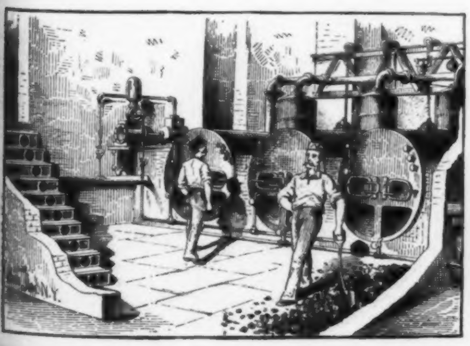


FIG. 1.—INTERIOR OF BOILER HOUSE AT JEWELL'S MILLS, BROOKLYN, N. Y., PRIOR TO THE EXPLOSION.

FIG. 3.—POSITION OF THE THREE BOILERS AFTER THE EXPLOSION, AT JEWELL'S MILLS, BROOKLYN.

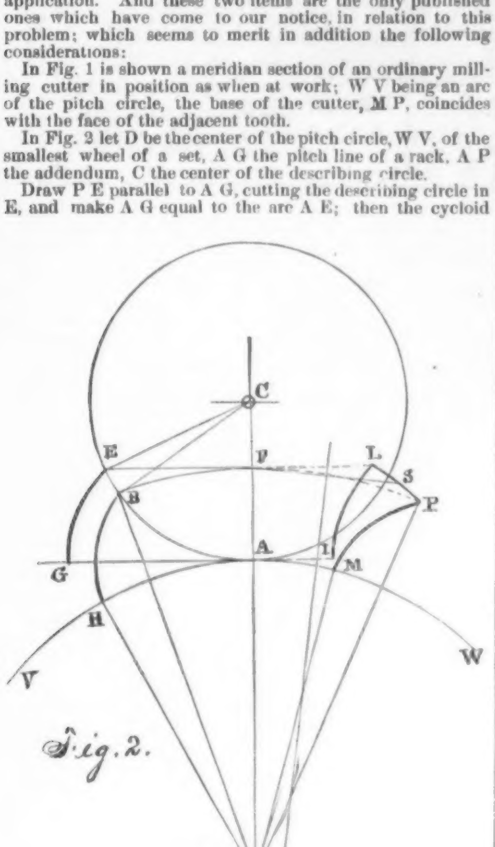
EXPLOSION OF TWO BOILERS AT JEWELL'S MILLS, BROOKLYN, N. Y., FEBRUARY 16, 1882.

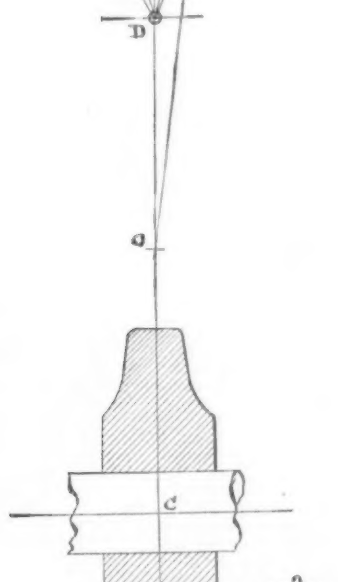
relating to the epicycloidal teeth) it is sufficient here to remark that neither of these elements appears in it at all; it may, therefore, be considered as intended for general application. And these two items are the only published ones which have come to our notice, in relation to this problem; which seems to merit in addition the following considerations:

In Fig. 1 is shown a meridian section of an ordinary milling cutter in position as when at work; W V being an arc of the pitch circle, the base of the cutter, M P, coincides with the face of the adjacent tooth.

In Fig. 2 let D be the center of the pitch circle, W V, of the smallest wheel of a set, A G the pitch line of a rack, A P the addendum, C the center of the describing circle.

Draw P E parallel to A G, cutting the describing circle in E, and make A G equal to the arc A E; then the cycloid





EQUIDISTANT GEAR CUTTERS.

E G is the face of the rack-tooth. Describe through P a circular arc about center D, cutting the describing circle in B; then making the arc A H equal to the arc A B, the epicycloid, B H, is the face of the tooth for the least wheel.

Now set off the arc A M equal to the half space, and draw M P equal and similar to H B, also make A I on the tangent at A, equal to the arc M A and draw the cycloid I L similar and equal to G E. Regarding then the line of centers C D as the meridian plane of cutters, it will be seen by reference to Fig. 1 that MP is the base of that for the least wheel, and I L the base of the one for the rack.

By using different pitch circles, and proceeding in like manner with each, a series of points may be determined, through which passes the curve P L, which is the locus of the highest points in the epicycloidal faces of all intermediate wheels.

A series of such intermediate faces is shown in Fig. 3, and since these differ the more from each other the further they extend from the pitch circles, it is evident that if they be so located as to cut the curve L P at equidistant points, the *greatest* variation between consecutive lines will be the same throughout.

A similar process might be employed in reference to the flanks of the teeth; but for present purposes this is not necessary, since the range of variation between them is less than that between the faces of the teeth; the latter only need, therefore, be taken into account in constructing a series of cutters.

The above constructions, then, give a key to the direct solution of the problem; for since every point on the curve L P corresponds to the termination of one of the faces, it is only necessary to subdivide into as many equal parts as there are cutters in the proposed series: any point of subdivision, as S, being joined with F by a right line, the perpendicular which bisects F S will cut C D at some point O, which evidently is the center of the wheel corresponding to that point S, the radius of the pitch circle, A O, being thereby determined.

We thus ascertain the range through which each cutter is to be used; the number for which it should be specially adapted being determined, of course, by bisecting each of the original subdivisions, and proceeding as above with the points of bisection. That is to say, this would be precisely true should the original points of division correspond to exact whole numbers of teeth. The probabilities are decidedly against this, consequently the integers to which these points most nearly correspond must be taken in determining the range of each cutter, and its exact location may be then found more exactly by bisecting the arc of the curve limited by the points corresponding to those integers.

Now, what is this curve? This question we do not pretend to answer; it has a sort of transcendental dependence upon the epicycloid, which is itself transcendental. But whatever be its exact nature, that small portion of it with which we have to deal may be treated as a circular arc whose center being found, the process becomes reasonably simple.

It need not be said that it is just as easy to make and to use a correct series as an incorrect one when once the numbers are ascertained; and in view of the fact that by the above method these can be found exactly, there is no reason for resting contented with approximations, when the epicycloidal system is used.

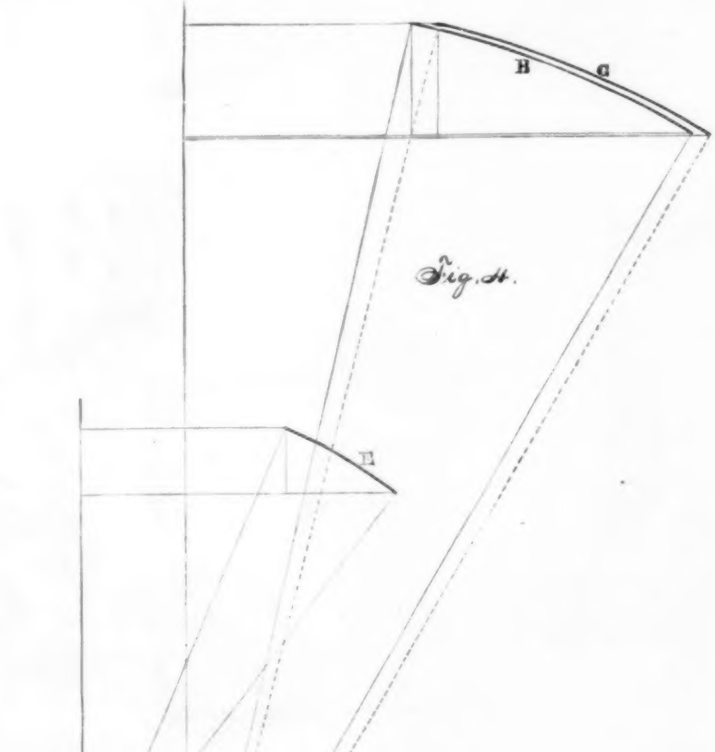
This being the case, it is worth while to consider the influence of variations in the addendum and in the size of the describing circle; and, pursuing this line of investigation, it appears that the magnitude and position of the locus L P are both affected by changes in either, to an extent appreciably affecting in its turn the higher terms at least of a series of any given number of cutters.

Thus, in Fig. 4, G represents this locus, and C its center of curvature, the basis of the system being the describing circle used by Prof. Willis, and the addendum being assumed equal to the diametral pitch. Whether this be the same as that assumed in the determination of the table given in the "Principles of Mechanism" or not, it is, of course, impossible to say, nor, for purposes of comparison, is it material: it may be noted here, however, that the upper numbers in a series of twenty-four cutters to cut from twelve teeth up to a rack, as determined from the conditions just named, are *lower* than those given by Prof. Willis.

Retaining the same addendum, but making the describing circle one-fourth larger, the locus L P changes to the position B, whose center of curvature is D. The effect of this upon the values of the terms in the series of twenty-four is to increase the upper ones, making them *higher* than those given in the table alluded to.

Next, the larger describing circle just mentioned being still used, the addendum was reduced one-half: whereupon the locus changes to E, with center of curvature F. This modification is attended with a still greater proportionate increase in the values of the higher terms in the series. But this is practically of less importance, since the length of L P, and therefore the amount of the variation in form between consecutive cutters, is diminished in a much larger proportion.

This point is of interest, because a series of cutters once determined on must of necessity be adhered to, whatever the system upon which it is constructed, and yet it may be desirable to reduce the addendum originally fixed upon, for the purpose of securing special conditions as to the relative amounts of approaching and receding action in particular cases; which, it thus appears, can be done without increasing the original variation.



EQUIDISTANT GEAR CUTTERS.

And to complete the list, it is to be added that Mr. Grant's formula gives, of course, the same results in all cases; while, therefore, these might be correct under certain conditions, they would certainly not be so under different ones. As compared with the series now under consideration, some of the values are higher, but in the upper part they are lower.

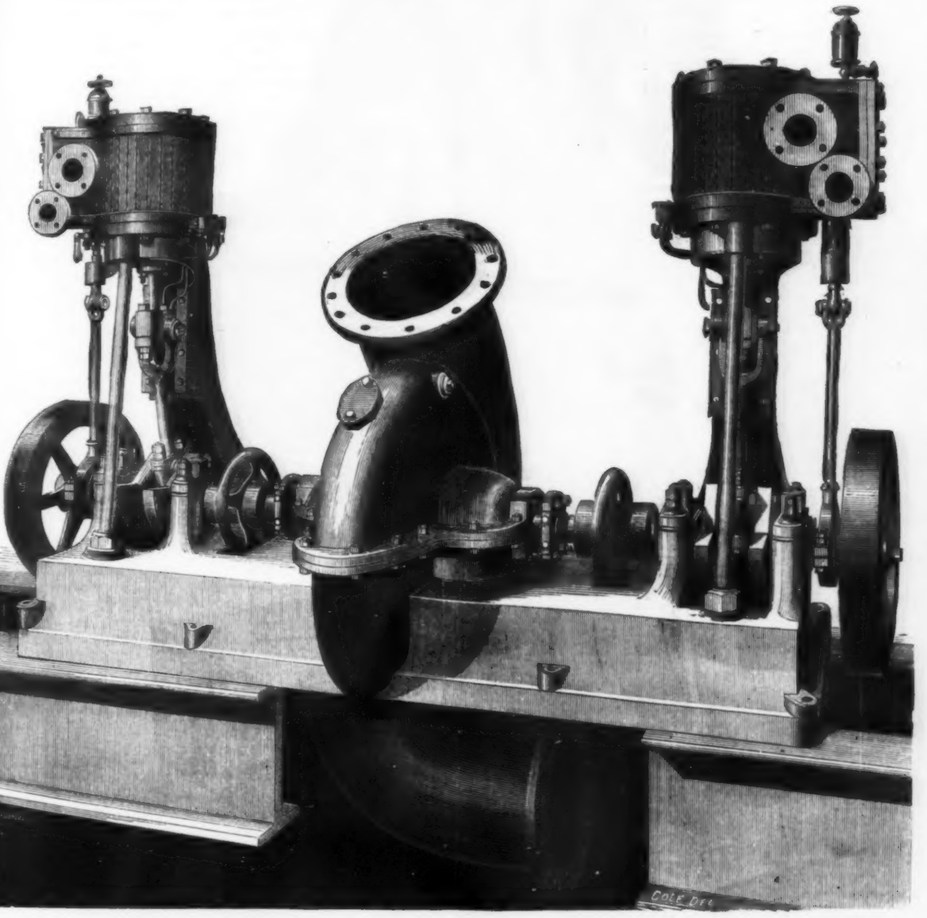
An analogous mode of procedure might be adopted with reference to other forms of teeth; but it would appear *prima facie* that no method of determining the values for a series of cutters can give precise results which does not take into account both the addendum and the path of contact. The fact that this path in the epicycloidal system is identical with the generatrix, renders comparatively simple the constructions which in other systems might be very complicated; but it appears, to say the least, extremely improbable that any formula can be deduced which is capable of general application, to different systems and under varying conditions.

But the epicycloidal teeth are used more extensively perhaps than any others, and, from what information we have been able to gather, current practice in this matter seems to be largely based upon the work of Prof. Willis, whose figures have been accepted, and, in the absence of any hint to the contrary, have been retained sometimes under varying

conditions. For cast wheels this would matter probably very little; but in the making of cut gearing for fine mechanism the tendency of the day is toward the attainment of the greatest possible accuracy consistent with a reasonable expenditure. We have here an instance in which the cost of production is not increased, so that any improvement in the direction above indicated is clear gain. Professor Willis's figures are at least not exact for the describing circles and addenda in connection with which they have been adopted in some cases; since the diameter of the former appears to affect most seriously the terms of the series, it would seem probable that his table would be more nearly correct for set of wheels in which the wheel of fourteen teeth has radial flanks; but this we have not considered it necessary to investigate more particularly, since what precedes enables us to determine to a unit the values of the terms in any proposed series of cutters for epicycloidal teeth.

CENTRIFUGAL SHIP'S PUMP.

WE illustrate a pair of pumping engines, one of a set of four which have been constructed by Messrs. W. H. Allen & Co., of York Street Works, Lambeth, for steamers now being constructed on the Clyde by Messrs. John Elder & Co. for the Java line of an Amsterdam firm. These ships are 3,000 tons, with 2,500 indicated horse-power. As will be seen, the pump, which is of the centrifugal type, is placed between two vertical engines, either of which can be put into gear by the coupling in a few moments. This coupling consists of a steel claw, sliding on two feathers on the shaft, being actuated by the small hand wheel; the claw portion of the coupling is covered with a brass shield. This coupling, which occupies very little room, accomplishes its work, and is very neat in appearance. The engine is fitted with cylinders 9 in. diameter, and the whole of the working parts,



IMPROVED CENTRIFUGAL PUMP AND ENGINES.

which are exceptionally strong, are made of selected steel. The bolts of the connecting rod and crosshead are turned down in the middle to the diameter of the bottom of the thread so as to give them more elasticity. The lubricators of these engines are of the most improved patterns, every joint and bearing being arranged so that it can be oiled when running at full speed. In the form of pump Messrs. Allen & Co. make, this arrangement is easily carried out, as it does not interfere with the pump, which can be got at without disturbing any part of the machinery, which cannot be done with side opening pumps. The pipes of the pump are 15 in. diameter, and this pump is capable of throwing into the condenser from 3,500 to 4,000 gallons per minute, or pumping from the bilge 1,100 tons per hour. Messrs. W. H. Allen & Co. are making no less than twenty different sizes of these pumping engines, which show that this form of pumping machinery is coming rapidly in favor with shipowners. The workmanship of these engines is exquisite, and the surfaces are so large and so well made that the chances of a failure are reduced to minimum. The cost of such a set of pumping machinery as that which we illustrate is very moderate—as nothing compared to the value of a steamship. Let it be remembered that this pump will lift overboard with ease, as we have said, 1,100 tons of water per hour, or if pressed, as much as 1,300 tons, and it will be seen how great a safeguard can be provided at a small cost. A great many ships founder because of leaks which admit less than one-half what these pumps could deal with.—*The Engineer.*

HERBERT LAWRENCE, who died recently in this city, was one of the oldest shipbuilders of this port. He became a member of the firm of Sneden & Lawrence, in 1816. Their first boat was the Bellona, Cornelius Vanderbilt, captain, launched in 1817. They launched the first Sound steamers, the President, New York, and others.

LAUNCH OF THE COLOSSUS.

THE double-turret ship Colossus was launched at Portsmouth on March 21st, from the same slipway down which, six years ago, the Inflexible glided into the water. The harbor squadron was dressed in the early morning with mast-head and over-head flags, while the dockyard and the ship itself were richly and profusely decorated. The Admiralty were largely represented on the occasion. Sir Thomas Brassey and the Controller of the Navy arrived in the Enchantress from Pembroke early on the previous morning; and later in the day Lord Northbrook (the First Lord of the Admiralty) and Lady Emma Baring, who performed the christening ceremony, Captain Hopkins (private secretary), Admiral Sir A. Cooper Key (Senior Sea Lord), and Admiral Hoskins (Junior Sea Lord) reached the town, the presence of the First Lord being announced on the morning of the launch by the hoisting of the Admiralty flag at the entrance of the dockyard and the firing of a salute from the Duke of Wellington. The ship was surrounded by a number of platforms, to which admission was gained by tickets, those at the stem and bows being gayly ornamented with flags and evergreens. On either side of the ship there were stands for the bands of the Royal Marine Artillery and Light Infantry Corps, which played alternately until the fall of the dogshores, when as the ship moved they united in playing "Rule Britannia." The crowd above and below was tremendous, the applications for tickets to Admiral Foley to view the launch being, with the exercise of the utmost possible economy as regards space, far beyond the amount of accommodation. Among the distinguished persons present were the present and the late First Lord, Prince and Princess Edward of Saxe-Weimar, the Duke of Richmond, Admirals Ryder, Chads, Fellows, and Lethbridge, Sir William and Lady Knighton, Lord Foley, and a large gathering of naval and military officers in uniform.

The whole of the arrangements connected with the launch were admirably devised and carried out, electricity being very extensively called into requisition. Not only was the ship "set up" and the "slices" driven home in the early morning under the illumination provided by the electric light, but the electric current was used to break the bottle against the stem, to cause the weights to fall upon the dogshores, to indicate the height of the tide, to announce the actual movement of the ship down the ways, and to put the musical box in operation which tinkled out the strains of "Rule Britannia," as the monster war machine backed away from the lady who performed the christening ceremony. The customary bottle of wine, which was concealed in flowers, was suspended on the top of a pillar of burnished gold, surmounted with a crown, and highly embellished with dolphins and mouldings forming a knotted rope. Fixed to the pillar was a plate inscribed with an engraving of the ship and the name of Lady Emma, to which were fitted the electric levers and buttons for letting go the bottle and causing weights to fall which knock away the dogshores and relieve the ship. The musical instrument to which reference has been made was inclosed in a beautifully manufactured box of bird's-eye maple, having gold mouldings and inlaid panels and was subsequently presented by Admiral Foley to Lady Emma Baring as a souvenir of the occasion. Twelve o'clock had been fixed for the launch, but as a matter of fact, the ship entered the water fully ten minutes before the appointed time. As the tide was suitable and the indications showed that she was ready to move, the proceedings at the supreme moment were somewhat hurried. The service was read by Rev. Mr. Williams, immediately after which, at a signal from Mr. Owen, the chief constructor, the dogshores were knocked away, and the ship instantaneously, without so much as a perceptible pause, slid down the ways amid the most tumultuous cheering and waving of hats. No better launch has ever taken place at Portsmouth, and the greatest credit is due to Mr. Barnaby, the constructor, and to Mr. Coward, the foreman, under whom the ship was built and launched.

Although the load displacement of the Inflexible is as 11,980 tons to 9,160 tons of the Colossus, the latter is the heaviest ship which has ever been launched at Portsmouth, her actual moving weight at the time of launching being 500 tons in excess of the launching weight of the Inflexible, and within 300 tons of that of her sister ship, the Edinburgh, which was launched at Pembroke on Saturday. The difference between her and the Inflexible is due to the fact that the Colossus is in a more finished state than the former ship, having been advanced five-eighths toward completion. The fore and after ends of the citadel have also been completely armored with sixteen-inch compressed plates, making a total of 1,290 tons. The prodigious weight of the hull necessitated special precautions being taken to enable the structure to support its own weight after the shores had been removed and before it had become buoyant on entering the water. Effective measures were also required to prevent any injury being done to the ship by sagging and local strains at the supremely critical moment when the stern becomes buoyant and lifts before the forward parts of the ship have left the ways. This temporary strengthening had taken place simultaneously with the progress of the monster, the double-bottom and decks having been effectually secured against collapse under pressure by a mass of diagonal and vertical shores. One of the most noticeable circumstances connected with the Colossus is the rapidity with which she has been constructed by Mr. Coward under the superintendence of Mr. R. Barnaby. The keel was laid on the 26th of July, 1879, and although the transition through which naval guns were passing from muzzle to breech loaders, and the necessary modifications which required to be made in the turret and hydraulic fittings, materially retarded the work, only a little more than two years and a half have intervened between her laying down and her launch.

The rapid progress of the Colossus is, doubtless, due in a great measure to the vigorous shipbuilding policy of the present Admiralty. At the same time, it must be pointed out that the ship is built upon the lines of the Inflexible, and that the many disputed issues which arose during the construction of the latter had been pretty well thrashed out through the means of a somewhat bitter controversy and the investigations of the committee which was subsequently appointed to report upon the whole subject. The air had been cleared, so that the Colossus was enabled to be pushed forward without any of the doubts and experiments which retarded the progress of the older ship.

But while the Colossus is in nearly all respects similar to the Inflexible, the turrets being movable and placed on either side of the middle line, she combines many departures from her prototype. These will be easily perceived from the following table:

	INFLEXIBLE.	COLOSSUS.
Length between perpendiculars	320 ft.	325 ft.
Breadth, extreme	75 ft.	68 ft.
Depth in hold	23 ft. 3½ in.	24 ft. 7 in.
Displacement at load draught	11,980 tons.	9,160 tons.
Draught of water, Forward	24 ft. 6 in.	25 ft. 3 in.
Draught of water, Aft	26 ft. 6 in.	26 ft. 3 in.
Draught of water, Mean	25 ft. 6 in.	25 ft. 9 in.
Indicated horse power	8,000	6,000
Estimated speed in knots	14	14
Complement of coal	1,200 tons	950 tons
Complement of officers and men	484	395
Armament:		
In turrets	Four 80 ton M. L. R. Woolwich guns.	Four 43 ton B. L. R. Armstrong guns.
On superstructures,	Eight 20 pr. saluting.	Four 6 in. B. L. R.
Along sides	Six Nordenfelt.	Ten Nordenfelt.
In tops	Two Gatling.	Two Gardner.
Length of citadel	110 ft.	108 ft.
Thickness of armor:	Iron	Steel-faced.
On sides of citadel	Outer, 12 in. Inner, 8, 12, & 4 in.	18 in. and 14 in. None.
On forward bulkhead	Outer, 12 in. Inner, 8. 10, & 4 in.	16 in. and 13 in. None.
On after bulkhead	Outer, 12 in. Inner, 6, 10 & 4 in.	16 in. and 13 in. None.
On turrets	O., 9 in. steel faced I., 8 and 7 in. iron	16 in. and 14 in. None.
Weight of hull at launching	3,460 tons.	3,956 tons.
Draught when launched	7 ft. 4 in. forward 11 ft. 7 in. aft.	12 ft. 5 in. 17 ft. 1 in.
Weight of armor in place at time of launching	488 tons.	1,290 tons

The principal differences between the Inflexible and the improved Inflexible relate to the coefficients, construction, armament, and armor. While the load displacement of the Colossus is considerably less than her prototype, she is both longer and deeper, though with a diminished beam. She will have the same speed, with 2,000 less horse power; and while she will carry in her turrets four forty three ton guns, as compared with the eighty ton guns of the Inflexible, yet as the former will be breechloaders they will enable her to penetrate twenty-two inches of iron and nineteen inches of steel. As Mr. Trevelyan last week remarked, the guns will send a chilled projectile through anything that floats, except a narrow belt on the water-line of a very few ships, "which it is fifty to one that a shot would never hit in battle." In addition to her turret guns the Colossus differs from the Inflexible in the fact that she will carry on her superstructure four six inch breech-loading guns—namely, two forward and two aft—having a very complete and extensive range. Several Nordenfelt machine guns have also been arranged to fire from the superstructure and from ports in the captain's cabin in any and every direction. Whereas, again, the Inflexible was built entirely of iron, including, with the exception of the turrets, the whole of her armor, the Colossus has been constructed throughout entirely of steel; and as the scantlings have been reduced in size without loss of strength, there has been a corresponding saving of dead weight. What many regard as a structural defect—viz., the unarmored ends of the Inflexible—has been servilely followed in the new ship. An armored deck three inches in thickness protects the ship below the water-line, where it is

not protected by the citadel, and under cover of which the steering gear and magazines are placed. But the French, while retaining this deck plating, have also taken the precaution of defending the stability of their monitors by means of an armored belt, the advantage of which in action is easily seen. The central parts of the ship are protected by Wilson's patent steel-faced armor of various thicknesses, the entire protection, however, whether on the side, citadel, or turrets, being of a single thickness. The total thickness of the sides is three feet, which is made up of a couple of strakes of teak backing, each eleven inches thick, and fourteen inches of compound armor. For eighteen inches above and the same depth below the water line the armor is eighteen inches thick, after which it tapers off to eight inches at about six feet below the water. Even should this enormous protection, however, be pierced by shot, the engines and boilers would remain untouched, for between them and the wall of the sides are a wing passage and the coal-bunkers. Above the water line the citadel ends are protected by thirteen inches of teak and thirteen inches of armor, but at the water line the backing is reduced to ten inches, and the amor is increased to sixteen inches. A very noticeable difference between the Inflexible and the Colossus is the absence in the Colossus of the raised, undulating, and peculiar form of the upper deck, which was adopted in the Inflexible to afford protection to the loading arrangements. In the new ship the surface of the deck will be comparatively level, the loading, which will be accomplished by hydraulic power, taking place in the citadel itself. These arrangements are the result of the change from muzzle to breech loaders. The hydraulic gear, which is being constructed by the Elswick firm, will be designed to raise a trough containing the ammunition and projectiles, and is fitted flush with the main deck. When the trough is elevated to its proper height to meet the lowered breech of the gun, impulse will be given to the rammer and the charge thrust into the chamber, after which the trough will descend and form part of the deck. The ship will be provided with two Whitehead torpedo tubes. These are placed on each side of the citadel under protection of the side armor, the projectiles being discharged above the water line. Instead of the armored cross as fitted on board the Inflexible, a V shaped armor tower, twelve inches thick, will be erected. This will be connected to the lower portion of the hull by means of an armored trunk six inches thick. The Colossus possesses cork belt coffer dams, and the Watt's water chambers, the purpose of which is to quell rolling, have also recently been fitted, those in the Inflexible having proved very satisfactory. Although supplied with a couple of masts, the turret ship will not carry sail, the masts being mainly for the purpose of hoisting boats in and out. The after mast will be adapted to lift and stow second class torpedo boats. No definite arrangements for the electric lighting of the ship have yet been made, but in all probability incandescent lamps will be used. A great boon will be afforded to the officers by the circumstance that the cabins are placed in the superstructure, where they will be well lighted and ventilated in all weathers. The bottom of the ship is coated on the starboard side with Dr. Sim's composition, and on the port side with that of the Maritime Company, usually known as Hay's composition. The propelling engines, nearly the whole of which with the boilers have been received at Portsmouth, are manufactured by Messrs. Maudslay, Sons & Field. They consist of two sets of compound engines, with inverted cylinders, and will be placed in separate engine compartments, divided by the midship bulkhead, thus forming a set of starboard and port engines giving motion to their respective propellors. There is only one funnel. Immense pumping power, as well as Friedman's ejectors, will be provided to free the ship of water. After the launch, the Colossus was taken alongside the yard for survey, after which she will be placed in the fitting basin to receive her machinery.—*Marine Engineer.*

LARGE PLATE-SHEARS.

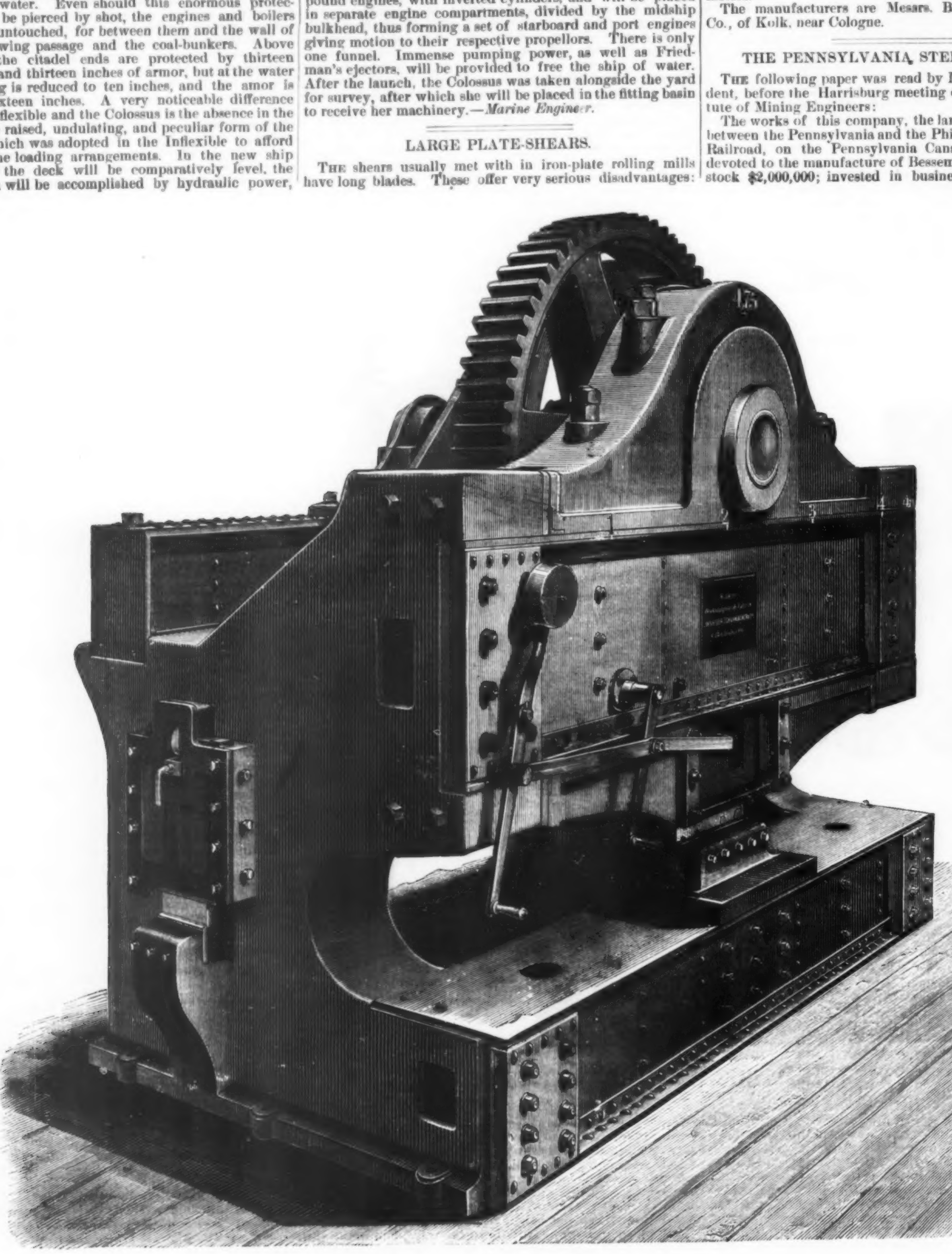
THE shears usually met with in iron-plate rolling mills have long blades. These offer very serious disadvantages: (1) The workmen who guide the plates at the two extremities are at same distance from each other, and have much trouble in keeping the direction true; (2) the motive power must be considerable, and (3) there is required a great consumption of steam, and, at times there occurs a breakage of the frame.

The shears which we represent in the accompanying engraving have short blades, which measure 0·7 of a meter. This machine, actuated with a velocity much greater than that communicated to tools with long blades, is capable of cutting the same number of plates in the same time. Straight lines can be cut with it with great precision, and round or oval cutting may be performed equally well. The apparatus is so constructed as to permit iron plates to be cut in both longitudinal and transverse directions.

The two frames, which are hollow, are of cast-iron, and connected by three riveted braces, and by three heavy cast-iron trusses which serve as supports for the bearings of the main shaft. The gearing wheels are of chilled iron, with a pitch of 105 mm., and with teeth 300 mm. in width. They produce no vibration. The shaft, which is of forged steel, is held by three bearings with metallic bushings. One of the frames carries a steam cylinder which has a diameter of 0·4 of a meter, and a travel of 0·6 of a meter. The opening in the frame at the level of the blades is 0·7 of a meter, which is sufficient to permit of the cutting of large plates, the maneuver being facilitated by a space of 3·5 meters left between the uprights. The workmen can move about easily and cut the pieces in any direction.

Small shears are arranged at one end of the frame for clipping the waste pieces. This apparatus, which has 0·3 of a meter blades with a travel of 0·06 of a meter, is capable of cutting plates as thick as 33 millimeters, and is provided with a disengaging gear worked by a lever. The machine is 4·5 meters in height and requires a space of 20 square meters.

The manufacturers are Messrs. Breuer, Schumacher & Co., of Kolk, near Cologne.



LARGE PLATE-SHEARS

THE PENNSYLVANIA STEEL COMPANY.

THE following paper was read by L. S. Bent, superintendent, before the Harrisburg meeting of the American Institute of Mining Engineers:

The works of this company, the largest in Harrisburg, lie between the Pennsylvania and the Philadelphia and Reading Railroad, on the Pennsylvania Canal, and are essentially devoted to the manufacture of Bessemer steel rails. Capital stock $2,000,000; invested in business, $5,000,000; wages per month, $80,000; employs 2,000 men; capacity, 100,000 tons of rails per year, which is being increased to 130,000 tons.

The plant, as it now stands, comprises five Bessemer converters, two 7-ton and three 8-ton converters, two 15-ton open-hearth furnaces in operation, and two 30-ton open-hearth furnaces in course of construction, one blooming mill, one rail mill, seven steam hammers, two blast furnaces in operation, two blast furnaces in course of construction, foundry, pattern shop, machine shop, blacksmith shop and frog shop, and merchant mill in course of construction.

Bessemer No. 1 was built in 1865, with two 7-ton converters, two spiegel cupolas, 3 ft. diameter, and three iron cupolas 6' 6" diameter, and has a capacity of 500 tons in 24 hours. The blowing engine is a horizontally condensing engine, with two steam cylinders, 40"x60", and two blowing cylinders, 54"x60". Pressure of blast, from 20 to 25 pounds.

Bessemer No. 2 was built in 1881. It has three 8-ton converters, served by two hydraulic ladle cranes, in two casting pits, and six hydraulic cranes for setting and drawing moulds, handling bottoms, etc. The hydraulic pressure is 300 lb.

per square inch. The blowing engine is compound horizontal, with a high-pressure cylinder, 25"x70", and low pressure 50"x70", with separate air-pump condensers, and also a Bulkley condenser attached. Pressure of blast, 25 to 30 lb. This engine was built in the Pennsylvania Steel Company's shops. There are four iron cupolas, 6' 6" diameter, and four spiegel cupolas, 3' diameter, blown by two No. 7 Baker blowers, or two 3-cylinder blowing engines.

The capacity of this Bessemer has not yet been determined, as it has only been in operation two weeks. There are many points of improvement over the old Bessemer, which cannot be described in this paper for want of time. All the castings, boilers, roofs, wrought iron work and engines of this plant were made and erected by the Pennsylvania Steel Company.

The Blooming Train is three high; rolls 34" in diameter, driven by a vertical condensing engine, 44"x54" cylinder. The capacity of this mill has never been determined, but is easily 600 tons in 24 hours. The ingots are delivered hot to the blooming mill from the Bessemer, and charged into four Siemens heating furnaces, six ingots being a charge for each furnace. The ingots are 14" square, and make four rails each. The blooms are cut under a 4-ton steam hammer (Sellers), and are loaded by a hydraulic crane on buggies, which are pulled by a water engine to the rail mill.

The Rail Train is three high; rolls 23" diameter, driven by a 40"x60" engine, with Bulkley condenser attached. This train has rolled 1,916 rails in 24 hours. The saw train is Gustin's patent. Two straightening presses and two drill presses handle the rails as fast as rolled.

Open Hearth Furnaces, built in 1875, consisted of two 6-ton furnaces, which were enlarged later to 15-ton capacity. The new open hearth furnaces in course of construction are each 30-ton. Each furnace has a casting pit, and the two are served by five hydraulic cranes.

A 14-ton Steam Hammer is placed between the blooming mill and rail mill. Under it heavy shafts, cross-heads, and piston rods are forged. When not in use for heavy work it hammers special steel into slabs and billets.

A 4-ton Hammer, adjoining the blooming mill, and a 1-ton hammer in the rail mill are used almost exclusively for slabs and billets.

The Foundry, 60'x225', has two cupolas, 5' diameter, two core ovens, and five 15-ton steam cranes. All ingot moulds are made here, and all castings for repairs and new work. The capacity of the foundry is 40 tons of finished castings a day.

The Pattern Shop has two circular saws, one Daniel's planer, one hand planer, a bandsaw, and one lathe, and bench room for 14 men.

The Machine Shop is 75'x230', and contains 13 lathes, from 96" to 10"; five planers, which take from 8' square to 2'' square; one 48" boring lathe, one 84" boring and turning machine, three 10' radial drills, two drilling machines, two shapers, two slotting machines, two horizontal boring machines, two bolt cutters, one pipe cutter.

The Blacksmith Shop, 60'x75', contains two 1 000 pound steam hammers and 14 fires.

The Boiler Shop, 75'x127', contains 3 drill presses, 2 shears, 1 punching machine, bending rolls, and 1 hydraulic riveting machine. In this shop all steam boilers, draught stacks, and iron roofs are built.

The Frog Shop, 60'x400' has a capacity of $30,000 to $40,000 per month in railroad frogs and switches, crossings and interlocking apparatus. It contains 14 planers, 6 drill presses, 2 slotters, 2 lathes, 1 milling machine, 1 shaper, 1 pin machine, 1 steam hammer, 1 combined punch and shear, 1 single punch, 1 steam riveter, 1 hydraulic bending machine, 10 fires, and 1 heating furnace. A new frog shop is to be put up immediately, 80'x400', with improved facilities.

Blast Furnaces.—No. 1, 14'x60', is blown by a vertical condensing engine, 84" blowing cylinder, 48" stroke; it has 4 pipe ovens, of Kent's pattern; the fuel used is anthracite coal and coke; the ores are native Pennsylvania, Virginia, and New Jersey, and Spanish and African. The product 50 to 60 tons per day.

No. 2, 20'x76', is blown by two vertical condensing engines 84"x48"; 3 Whitwell stoves, 18'x60'; fuel and ores are the same as No. 1; product 840 tons per week. The product of both furnaces is used in the Bessemer.

No. 3 and No. 4, blast furnaces, are each 16'x65'. They are to be blown by vertical condensing engine, 70"x48", 2 blowing cylinders to each engine, with capacity for 22,000 cubic feet of air per minute. These engines are being built by the Pennsylvania Steel Company. Each furnace has 3 Whitwell stoves, 18'x60', and will use the same fuel and ores as Nos. 1 and 2.

A Merchant Mill is in course of construction. The building, 100'x400', will contain 1 12-inch roll train, and 1 20-inch roll train; the first driven by a horizontal Hughes & Phillips engine, 22"x20", the second by a horizontal Porter-Allen engine, 32"x48".

The Heating Furnaces are Sweet's patent.

THE PROGRESS OF THE METALLURGY OF GOLD AND SILVER IN THE UNITED STATES.

By T. EGLESTON, Ph. D.

AMALGAMATION, whether in the barrel or the pan, was first used only for ores that are now called free-milling—that is, which will amalgamate immediately with the mercury. But it became evident soon that there was a large amount of ore which would not amalgamate. It contained sulphur and other substances which either prevented the action of the mercury altogether or caused a great loss of it. Such ores were called rebellious, and at first were not used; afterward they were roasted, the principal object of the roasting being not only to drive off the sulphur which was present, but by adding a little salt to convert the silver into chlorides which could be easily attacked by the mercury, which process was called the Reese River Process in distinction from the Washoe, which is the free-milling.

Up to this time stamping had generally been done wet in order to avoid the losses occasioned by the dust, as there was no reason why in the Washoe process the wet ore should not be delivered to the pans as soon as it is settled sufficiently to form the "pulp," but with rebellious ores in regions where fuel was generally scarce, too much heat would have to be used in driving out the moisture from the ore,* and dry-stamping took the place of the wet. As the ore came from the mine damp, drying floors, made by running the flues of the roasting furnace backward and forward under the iron plates covering the floors behind the stamps, were used, and the ore from the mine was spread out over these plates until it was dry. As there was nothing but the force of the blow from the stamp-head to deliver the ore from the screens, the operation was slower, and as no water current carried the ore away from the front of the stamps, endless chains were placed in the dust-tight boxes which inclosed the front of the mortar-screens, which delivered the crushed ore into bins in the roof of the works, whence it was delivered by spouts into the furnace.

Every kind of furnace for roasting was invented and tried. These were usually some kind of reverberatory furnace, and were the subject of a large number of patents, and were altered and modified with more or less permanent success. Attempts were made to make the work wholly mechanical by the use of revolving cylinders into which the ore and salt were charged by machinery, in order to get rid of the difficult hand labor required, and the necessary exposure to fumes in roasting in ordinary reverberatory furnaces. A few of these survive in the Bruckner* and Teates furnaces, but as a general thing the cost of repairs to these contrivances, and the necessity of more engine-power, or of separate engines in the absence of machine-shops near at hand, increased the expense of working beyond the gain in diminished labor.

On account of the large loss both in mercury and in silver which are carried off in the tails, mills† called tail-mills have been erected, where, notwithstanding the large loss in mercury which is known to exist in the treatment, there is a constant increase in the quantity of mercury, and very often a large yield in silver. These mills have no work to do unless the tails are accumulated by damming the valleys through which the tail streams pass. When the accumulated tails have been treated, the mills have no further use, and very often the heavy freshets do the work first by sweeping the tails away. Sluices of great length and width have been put up, but their tails are still rich.‡ Many machines have been invented for catching mercury and amalgam by making the tails pass over revolving blankets, rubbers, revolving amalgamated plates, and many other contrivances, but they are not as yet successful in the commercial sense.

When lead, copper, or zinc were present in the ores in any considerable quantity they became so rebellious that amalgamation was out of the question, and smelting, with its necessary adjunct of concentration, became necessary. As the dressed ores were rich, and contained a large product condensed into a small one, and as this product was usually sold, sampling § works sprung up, in which the value of a large quantity of ore was carefully ascertained by processes more or less mechanical, in which, as rapidity of execution as well as correctness of results were necessary, a number of tools for reducing the ore to powder now generally used were invented.‖

The first attempts at smelting, as they were usually conducted by persons of no great experience, were not very successful. In fact, the early history of the now very successful American methods is a record of failures. When the smelting of silver ores became a necessity, English methods were first introduced by the Cornish miners, only a few of the German and Swedish furnaces being used. But as the English type of furnace requires a considerable amount of good fuel, of a kind not generally found in the West, and the use of wood in them requires great skill, shaft furnaces gradually took their place, for the most part for treating ores containing gold, copper, silver, and lead by smelting.¶ Some of the processes adopted from the old works in Europe found themselves in circumstances where the conditions of transportation, labor, or fuel were such that they could not compete with other districts, so that they gradually disappeared, and were succeeded by the same processes in a new dress or in a new phase to such an extent that the plant and the process as it is now used in the West would hardly be recognized by their inventors. Little by little it was ascertained that when the ore contained any volatile material, although it might be in small quantities, it would carry off with it very considerable portions of the precious metal; and then arose the idea of condensing chambers, until gradually, without any one person having invented them, the methods have grown into the simple and very beautiful processes which are now in use in the West.

At first the only fuel used was charcoal, and this, as wood was scarce, was sometimes made from dead or from float wood or from woods too light for the purpose, so that it very often happened that the charcoal would crush by its own weight, and would not stand a charge in the furnace at all. It then became evident that the ores must have a comparatively high yield, and that as they usually had a gangue composed for the most part of silica, coke was necessary, and this, with from ten to twenty per cent. of ash,** was imported from the East or from Europe at an expense in some of the works of forty dollars a ton. As it became evident that coke was the necessary fuel, it also became apparent that something must be done to reduce the cost, and also the cost of the refractory materials. Water-back furnaces were then introduced, which consisted of cast or sheet iron boxes riveted together, surrounding the hottest part of the whole of the furnace and cooled with water. These furnaces were for the most part open-breast furnaces with front hearths, and were continually getting out of order from the formation of sows and bears which occasionally stuck to the bottom or formed engorgements in the furnace higher up. To avoid these the Ahrent's tap was invented, which keeps a very considerable quantity of lead on the hearth of the furnace at all times, and allows of the casting being done without interfering with the interior. In other works where copper is in large quantity the ores are smelted for copper, and the silver and gold concentrated in one of the products, from which it is separated in the wet way by the skillful adaptation of old processes.††

It now became evident that there were considerable mechanical losses from the material being carried up and out of the chimney, so that in some instances in Utah as much as ten or even fifteen or twenty per cent. was carried off in this way. Attempts were then made to collect this material as is done in Europe in condensation chambers of large size and extent, and several systems of doing it have been invented. The simplest, the cheapest, and the most recent of these is used at Mansfield Valley, near Pittsburg, Pennsylvania,‡‡ and is an adaptation of the flue leading to the chimney by dividing it in two sections vertically. In the lower one of these, partitions eighteen inches high, placed four or five feet apart and one third of the height of the flue, catch the dust by gravity, and as there is no velocity below, it remains there. The gas circulates above.

Generally the silver and the gold in a district where lead ores can be had, are concentrated in a pig lead improperly called "base bullion." In some few cases in the early days the German method of cupellation was used, but as this requires a maximum consumption of fuel, great skill, and a market for litharge, it was quickly superseded by the English method, which requires less skill, makes no litharge for sale, but required the poor lead to be concentrated into a rich one and that treated for gold and silver. The Patterson process by crystallization for enriching the lead previous to cupellation was never extensively used here, principally because at the time when there was a large amount of work to be done the process had already been superseded. The lead directly from the furnace is now enriched by zinc desilverization,* and the rich lead cupelled in an English furnace.

The history of this process is very peculiar. Invented in 1842 by Karsten, it was declared a failure after a prolonged investigation by that very able metallurgist. It was reinvented by Crooks in 1858 in England, where it was not very successful, and was brought to this country as an English process. It was tried again at Tarnowitz, in Silesia, and was more or less of a failure there, and was then reintroduced into this country, and so many improvements made in it that to-day the American modification of it has become the perfection of a process, and the furnace used a type furnace.

In order to use the method of desilverization by zinc it is necessary that the lead should be very pure. To purify the lead small refining furnaces were used in Germany, containing two to three, and subsequently from five to six tons each. But in this country one of the first improvements made was the softening or purification of the lead in a furnace containing from fifteen to twenty, and subsequently as high as twenty-six tons; but as the hearth of such a furnace was difficult of construction, it was simply made in a cast or wrought iron pan. This softened lead had to be discharged from the furnace, which was not an easy matter, and the late Mr. Steitz invented a siphon † to do it, which seemed to be the perfection of an instrument for this purpose.

The refined lead is stirred with zinc; the zinc-scums carrying the silver with them are liquated to separate the excess of the lead, and the result is a very rich zinc alloy, containing a large amount of lead, which is granulated and distilled in retorts. The distillation in retorts promised at one time to wreck the process, as it had to be effected in small furnaces ‡ surrounded by coke, and the number of retorts broken was large, notwithstanding the use of Steitz's siphon. Petroleum was then tried with great success, lessening the breakage of the retorts due to the charging of the fuel and the poking of the fire. Subsequently Mr. Faber du Faur invented his tilting furnace, which allows of pouring the rich silver lead out of the retort without disturbing it, thus removing all the difficulty. The silver lead from which the zinc has been distilled is cupelled in an English furnace and cast into pigs. The lead from which the silver has been removed is refined in a furnace similar to the softening furnace, called a calciner. All the lead so refined is of the highest quality fit for the manufacture of white lead. It is produced almost as a by-product, and at a low cost.

The improvements in cupellation have been, first, the invention of the iron cupel surrounded by water, by the late Mr. Steitz, of St. Louis, upon which the lead could be brought up to fine silver, and the later invention of Mr. Eurich, of the Pennsylvania Lead Company, of going from the lead riches to silver 996 fine, on a hearth made of Portland cement, and casting directly from the cupel into silver bricks by a simple arrangement for tipping the cupel.§

It sometimes happens that silver can be extracted from its ore in the wet way. There are three principal methods which have been used for this purpose. The first was introduced in 1849 by a German named Augustine, and consists ‖ in transforming the ore into chloride by roasting the ore to drive off the sulphur and other impurities, grinding the roasted ore and then roasting with salt to form chlorides; then dissolving out the chlorides with a saturated solution of salt, precipitating the silver with copper, compressing and melting the silver. It is usual to concentrate the silver into copper mattes for this process. Shortly after the invention of this process, another, much simpler, was invented by Ziervogel,¶ which consists in roasting mattes to produce sulphates, decomposing all these sulphates except that of silver, and then dissolving out the sulphate of silver with hot water. Simple as it appears, this process is exceedingly difficult to execute, for it requires a very high degree of skill to seize the exact moment when all the sulphates of the other metals are decomposed and none of the silver is. If the sulphates are not all decomposed the silver is precipitated by them; if they are, there is danger that the silver sulphate also will be decomposed, and it will then be lost, as the oxide is not soluble. The practice, therefore, is to leave a little of the sulphates of these metals undecomposed, as the loss in this case can be calculated beforehand, while no one can tell what it will be in the case of too much roasting. As these residues are always rich, they are often treated by the Augustine process, the two being very advantageously used together in this country.**

In looking at the silver process as a whole, and comparing the cost, we find that the relations between the relative cost and quantity of silver extracted were very interesting.

	Relative cost.	Relative loss.
Amalgamation	2·2	2·0
Augustine process	1·8	2·0
Ziervogel "	1·0	1·0

The Ziervogel process is, both as to cost and residues, twice as advantageous as the others.

Still another process was invented in 1858 by an Austrian of the name of Von Patera, which consists in roasting, as in the Augustine process, leaching with hot water before roasting with salt in order to dissolve out any soluble salts, roasting with salt, then dissolving the chlorides with hyposulphite of soda, precipitating the silver with polysulphite of sodium, and then reducing the sulphide of silver. This process is

* "The Stamp Mills of California," *Engineering*, London, England, vol. 31, p. 634.

* *Engineering*, vol. 22, p. 575.

† "Treatment of Tailings." *Engineering*, vol. 30, p. 395.

‡ *Engineering*, vol. 30, p. 395.

‖ *Engineering*, vol. 22, p. 495.

§ *Engineering*, vol. 22, p. 495, figs. 5 to 12.

¶ "Transactions of the American Institute of Mining Engineers," vol. 4, p. 275.

** The high percentage of ash in the coke has in several instances caused the failure of works which with a suitable fuel might have been successful.

†† "Trans. Amer. Inst. Min. Engs." vol. 4, p. 276.

‡‡ "Annals New York Acad. Sci.," vol. 2, p. 106.

* "Annals New York Acad. Sci.," vol. 2, p. 86.

† "Annals New York Acad. Sci.," vol. 2, plate 7, fig. 6; plate 9, fig. 10.

‡ *Ibid.*, p. 98.

§ *Ibid.*, p. 108.

‖ "Trans. Amer. Inst. Min. Engs.," vol. 4, p. 295

¶ "Trans. Amer. Inst. Min. Engs.," vol. 4, p. 246.

** *Ibid.*, p. 295.

easily carried out, in that the reagents can readily be had, and that none of them are wasted; but both the lixiviation and the precipitation require such nice distinctions and such an exact chemical knowledge that it has not been very successful.

The bullion which is produced as the result of treatment of any of the ores usually contains some small quantity of the base metals besides the gold and silver. The gold from California generally contains about twelve per cent. of silver, that from Australia four to six per cent. The amount varies from three per cent. to about twenty-five per cent. The silver bullion often contains gold, as in the case of the Comstock, where one third of its value is gold; and these metals must be separated in order that they may be alloyed to their proper standards for commercial uses. Neither pure gold nor pure silver is of any use commercially except for electroplating; for all other purposes they would be much too soft. The process of separation is called parting. To effect this an alloy is made by melting, which usually contains three parts of silver to one of gold. In a single instance in California this alloy is three of silver to two of gold. The formation of this alloy is called quartation or inquartation. It is granulated and subjected to one of three different processes; the silver is dissolved out by either nitric or sulphuric acid, and in both cases the residue not dissolved will be gold. The nitrate of silver siphoned off from this is diluted with water and precipitated with salt. The chloride of silver so formed is reduced to a metallic state with sulphuric acid and zinc, and the silver melted into bars whose fineness is stamped on them, and they are then used for commercial purposes. In the case of sulphuric acid, sulphate of silver is formed, which is diluted with hot water, and precipitated as metallic silver by copper. The spongy silver is pressed into cakes by a hydraulic press and melted into bars. The gold is collected, melted, and run into bars. The nitric acid method has been generally abandoned, because it poisons the neighborhood with fumes. The sulphuric acid process, which is a little cheaper, has taken its place, except in California, where a very beautiful method, invented by Mr. Gutzkow,* has taken its place. This method, which is very ingenious, much quicker, and gives better results than the others, was introduced in San Francisco in 1867. Most of the alloys are not granulated; they are inquartated and dissolved in sulphuric acid in bars. The sulphate of silver is crystallized and a solution of sulphate of protoxide of iron run through it, which reduces the silver to a metallic state; the iron solution becomes sulphate of sesquioxide of iron, and is restored to its original condition with fresh iron and used again. The silver is pressed and melted as before, and the gold from the pots treated in the same way. This process is not only very simple, but is in a chemical way one of the most beautiful known.

The amount of silver produced in the United States previous to 1858 was so insignificant that no statistics have been recorded. In that year it was only $500,000; in 1859 it was only $100,000; in 1860 it was $150,000; but in the following year, 1861, the amount of silver began gradually to increase, until the year 1870, when it was $16,000,000. The total amount produced in this decade from 1860 to 1870 was $84,300,000, the lowest amount being $150,000, in 1860. From 1870 to 1880 the amount of silver becomes a very considerable factor in the world's production of this metal, the highest amount being a little over $45,000,000, in 1878, and the lowest $16,000,000, in 1870, the total production for the decade being $374,922,260. If these amounts of silver are added to the amounts of gold shown in the table, in the last number of the *Quarterly*, p. 80, it will be seen that for the decade from 1860 to 1870, the highest production of precious metals was in 1869, $61,500,000; and the lowest was $43,700,030, in 1862, the total being $555,150,000. For the next decade, from 1870 to 1880, the highest production was in the year 1878, $96,487,745, and the lowest $66,000,000, in 1878. The largest amount of silver produced by any one State during the year 1880 was $17,000,000, obtained in Colorado, and the next largest $10,000,000, from Nevada.

Year.	Silver.	Total Gold and Silver.
1858	$500,000	$50,500,000
1859	1 0,000	50,100,000
1860	150,000	46,150,000
1861	2,000,00)	45,000,000
1862	4,500,000	43,700,000
1863	8,500,000	48,500,000
1864	11,000,000	57,100,000
1865	11,250,000	64,475,000
1866	10,000,000	63,500,000
1867	13,500,000	65,225,000
1868	12,000,000	60,000,000
1869	12,000,000	61,500,000
1870	16,000,000	66,000,000
1871	23,000,000	66,500,000
1872	28,750,000	64,750,000
1873	35,750,000	71,750,000
1874	37,324,594	70,815,496
1875	31,727,560	65,195,416
1876	38,783,016	78,712,182
1877	39,793,573	86,690,963
1878	45,281,385	96,487,745
1879	40,812,132	79,711,990
1880	37,700,000	73,700,000

Such enormous productions of the precious metals have not been without their influence on the relative value of gold and silver in other countries. The United States is one of the largest producers of the precious metals, notwithstanding, as the statistics show, there has been a gradual falling off in the production of gold, and the highest limit of silver appears to have been in the year 1878, since which time the decrease in the production of the Comstock has brought down the production of silver from its maximum in 1878, nearly $8,000,000, and it seems likely that this decrease will continue.

The amount of gold consumed in the United States for purposes of art and ornament during the year 1880 was larger than for several previous years. The following table from the Report of the Director of the Mint, which is a mine of information for those interested in the production and distribution of the precious metals, gives the returns of the New York Assay Office for that year:

BARS MANUFACTURED.*

	Gold.	Silver.	Total.
From United States coin (defaced)	$4,929	$982	$5,911
Foreign coin	260,222	72,668	332,890
" bullion	1,007,400	278,622	1,286,022
Domestic "	2,988,422	3,863,126	6,851,548
Plate, etc.	394,871	144,992	539,863
Total	$4,655,844	$4,360,390	$9,016,234

From the whole United States this amount is much larger; but leaving out the foreign bullion altogether, the following table gives the estimate of the total gold and silver used in the whole United States for industrial purposes during the last year:

	Silver.	Gold.
Domestic bullion	$4,000,000	$5,000,000
U. S. coin	600,000	2,500,000
Plate, foreign bullion and coin	400,000	2,500,000
Amount consumed	$5,000,000	$10,000,000

The consumption of the precious metals for purposes of art and ornament has been the subject of estimates by many distinguished statisticians, but at the best can only be approximated. In 1827 Humboldt placed it at 375,000 ounces, or one fifth of the world's production at that time. In 1822 Lowe estimated it at two-thirds. William Jacob estimated it at 988,000 ounces, which was double the average annual production between 1821 and 1830. Dr. Soetbeer, of Germany, gives the following tables of the consumption of the precious metals for jewelry and other industrial purposes in the various countries of the world:†

GOLD.

	Consumption in ounces.	Reduction by Old Material used.	Total Consumption.
United States	529,000	10 per cent.	476,000
Great Britain	703,000	15 "	598,000
France	739,000	20 "	591,000
Germany	518,000	20 "	412,000
Switzerland	529,000	25 "	397,000
Austria	102,000	15 "	87,000
Italy	212,000	25 "	159,000
Russia	106,000	20 "	85,000
Other countries	176,000	20 "	141,000
Total	3,614,000		2,946,000

SILVER.

	Consumption in ounces.	Reduction by Old Material used.	Total Consumption.
United States	4,233,000	15 per cent.	3,789,000
Great Britain	3,175,000	20 "	2,540,000
France	3,528,000	25 "	2,646,000
Austria-Hungary	1,411,000	20 "	1,129,000
Switzerland	1,129,000	25 "	847,000
Italy	882,000	25 "	662,000
Russia	1,411,000	20 "	1,129,000
Germany	3,528,000	25 "	2,646,000
Prussia	1,870,000	——	1,411,000
Total	21,167,000		16,799,000

Other estimates give the entire consumption of the precious metals in Europe and America for industrial purposes in 1880 as from $45,000,000 to $55,000,000 in gold, and from $25,000,000 to $30,000,000 in silver.

From 1831 to 1880 the estimated consumption of gold for industrial purposes was 73,000,000 ounces, or 32·6 per cent. of that produced. For silver it was 511,000,000, or 25·2 per cent.

Of the world's product of bullion it is estimated that one third is used up and lost in the wear and tear of coins and articles made for use or ornament, one-third is used for manufacturing purposes, and one-third goes to supply the increased demands of trade. The amount lost by the abrasion of coins is shown by the fact that the avarage life of an English sovereign is eighteen years, by which time the coin has lost three quarters of a grain and is no longer legal tender. Dr. Soetbeer* states that the annual loss from this source in civilized countries reaches 28,000 ounces of gold and 1,600,000 ounces of silver.

The following table † shows the amount of gold and silver produced in the world in the years 1877, 1878, and 1879:

	1877.		1878.		1879.	
	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.
United States	$47,897,390	$39,793,573	$51,206,360	$45,281,385	$38,899,858	$40,812,132
Russia	27,226,668	467,844	27,967,697	448,016	26,584,000	415,676
Australia	29,018,223	....	29,018,223	....	29,018,223	....
Mexico	996,898	27,018,980	996,898	27,018,940	989,161	25,167,763
Germany	204,697	6,135,877	205,361	6,938,073	205,361	6,938,073
Austria	1,196,278	2,119,948	1,196,278	2,161,515	1,062,031	2,002,727
Sweden	2,658	54,038	6,001	52,708	1,994	62,485
Norway	....	188,052	....	166,270	....	166,270
Italy	72,375	17,949	72,375	17,949	72,375	17,949
Rest of Europe	....	2,078,380	....	2,078,380	....	2,078,380
Argentine Republic	78,546	420,225	78,546	420,225	78,546	420,225
Colombia	4,000,000	1,000,000	4,000,000	1,000,000	4,000,000	1,000,000
Rest of S. America	1,993,800	1,039,190	1,993,800	1,039,190	1,993,800	1,039,190
Japan	265,840	706,649	295,746	728,846	466,548	916,400
Africa	1,993,800	....	1,993,800	....	1,993,800	....
Total	$113,947,173	$81,040,665	$119,031,085	$87,351,497	$105,365,697	$81,031,220

Dr. Soetbeer ‡ gives the totals as:

1877. Gold	1877. Silver.	1878. Gold.	1878. Silver.
$121,514,026.	$96,855,376.	$122,058,368.	$104,126,608.

1879. Gold.	1879. Silver.
$104,245,987.	$102,229,521.

These tables show that the United States is by far the greatest producer of the precious metals, Russia being the only one which produces anything like as much gold, and Mexico the only one that approaches it in silver.

The amount of precious § metals sent to the East, the greater part of which goes to India, has been estimated by Dr. Soetbeer as:

	Gold in Ounces.	Silver in Ounces.
1831–1840	35,000	7,750,000
1871–1880	423,000	38,000,000
1831–1880	19,700,000	1,376,000,000

In the period from 1871–1880, which is most reliable, the consumption of gold by this means was 47,000 ounces, and of silver 4,200,000 ounces. In India alone the imports in the last forty years have exceeded the exports of these metals by $400,000,000, of which only $8,000,000 have been coined as money.

The amount of the precious metals hoarded or put out of circulation either as objects of art or ornament is becoming greater with every decade. It appears from the data given above, that the total annual consumption of the precious metals for purposes other than coinage is about 3,600,000 ounces of gold and 21,000,000 of silver. It has been estimated that the entire amount of gold now in the world is only equal to that which has been produced in the last twenty-five years, and that of silver to that produced in the last eighty years. No one has as yet been able to satisfactorily explain what has become of all the rest of the precious metals.

Only an estimate can be made of their wear and tear, which is an irretrievable loss, either in the abrasion of coin or in the use of leaf or of the pure metals for plating purposes. Add to this the amount lost in lead, copper, and other metals, which do not contain enough of it to separate, and it is not a matter of surprise that, notwithstanding the enormous yearly increase, the estimate of the total amount supposed to exist in the world during any period is not perceptibly greater.

In all the methods for the extraction of the precious metals there are considerable losses. With the perfection of processes, the main object is to reduce them, or else to cheapen the labor of extracting the ores. These losses are greater than is usually supposed, because as a general rule systematic assays of the tails are not made. Yet it is known that the tails contain precious metals, and they are sometimes reworked with profit, especially those from the silver mines. An interesting investigation was made some years ago, the results of which are given below,‖ showing the great loss in some of the mills.

	Yield of Ore in the Mill.	Remaining in Tails.		Total in Tails.
		Gold.	Silver.	
At the mill	$18 60	$10 04	$3 14	$13 18
Same tailings 350 ft. from mill	18 60	5 02	3 92	8 98
Average yield of 150 tons	3 50	13 55	6 28	18 83
Average yield of 150 tons	3 50	8 79	6 28	15 07
Slime from end of sluice 310 ft. long	....	56 00	33 30	89 00

* Burchard, "Production of Gold and Silver." Washington, 1881, p. 356.

* Report Director of the Mint, 1880, p. 19.

† *Engineering and Mining Journal*, vol. 32, p. 183.

* *Engineering and Mining Journal*, vol. 32, p. 182.

† Report Director of the U. S. Mint, 1880, p. 159.

‡ *Engineering and Mining Journal*, vol. 32, p. 182.

§ *Ibid.*, p. 183.

‖ Report of the U. S. Mining Commissioner, 1872, p. 17.

It was also found that water from the mills three-fourths of a mile below them contained in suspension, as an average of twelve assays, $0·018 per gallon. There were in this locality 576,000 gallons of this water flowing away in twenty-four hours, or a loss of $339.84. It was estimated that the annual loss of two mills working 250 days in the year was $84,960. From these and similar data the conclusion is drawn, that the loss is between fifty and sixty per cent. of the total yield of the ore.

It is a matter of great interest to ascertain what the cause of these losses is, in order to learn how far they are capable of remedy. The first of these is undoubtedly a desire to get the largest possible output from the mill. This makes the ore too coarse to have all the gold and silver amalgamate, as part of it may not be released from the gangue. It would be much better to get the output by a more careful sizing of the ore, not forcing the stamp to do the work of a Blake's Crusher, and not sending to the mortars any ore fine enough to pass the screens. This is a matter of some importance, for it has been found with all kinds of stamps using screens, that it takes just as long to get crushed ore which has already passed the screens out of the mortar, as it does to crush and force it out. Too fine crushing is also quite as bad, for it produces "float," and is quite likely to put the precious metals in a condition in which they will not amalgamate.

Supposing that the losses which result from improper working do not exist, there are a few causes of loss which do not always amount to much, but which, in the early days, were a source of considerable loss. It has been found that any holes in the castings of the stamps, pans, etc., will attract the amalgam, and that it will even be carried into holes deep in the interior of the piece. This was a source of profit in the early days to those who recovered the precious metals when the worn out castings were melted. Another loss may be in cleaning the plates by taking off the amalgam too thoroughly. It is a well-known fact that new plates do not act as readily as old ones; the difference is so great, that when the mills can afford it, new plates are coated with gold or silver amalgam. Gold and silver will go much quicker to amalgam than to mercury. Too slow a current of water will keep the surface of the plates covered with a film of sand; a too rapid current will prevent the gold from being caught. If the gold is attached to a piece of the gangue rock which is relatively large, the specific gravity may be so reduced as to prevent the particles from coming in contact with the mercury. If the blankets are left too long without washing, so that the hairs become charged, the fine particles of gold are lost. If all these causes of loss are avoided, there are still others. For if the mercury is not kept clean or made so by chemicals, the "quick," having an extremely thin film upon it, does not act upon the gold or silver. Exactly the same effect is produced to a small extent when the rock is soapy, as is the case with some of the magnesian and aluminous rocks. If there are too few amalgamating machines, if the sluices are too short, there is also a loss. A very important source of loss is the flouring of the mercury from too rapid motion, or from the too free use of chemicals. In such cases steam may be used, if it is live steam fresh from the boiler, which prevents flouring by the expansion of the globules. If steam from the engine is used as a matter of economy, it often increases the loss, as very minute particles of grease are always carried off with it, which coat the mercury. The cause of the losses on the concentrates has already been discussed.—*School of Mines Quarterly.*

GOLD AND ITS MANUFACTURES.

WATCH CASES, THEIR USES, MATERIALS, AND QUALITIES.

AMONG the many articles in common use made of gold, nothing attracts our attention more than do watch cases. Some of the most beautiful specimens of art in metallic work may be found in the form of gold watch cases; and without a correct knowledge of the rules and principles herein laid down and explained, a very erroneous judgment may be formed in regard to their valuation.

Two cases of the same pattern and size may be of very different value, as two of the same weight precisely by the scales may also be of a difference in value equal to half the worth of either. This is mainly owing to the carat of the gold, the style and mechanical finish of the cases.

Gold cases manufactured in Europe are usually supposed to be made honestly; makers are prohibited by law, or perhaps as much by custom, from making work of lower carat than indicated by stamp. But in this country case makers, and indeed all manufacturers, are permitted to execute work with any degree of deception they wish. They can not only make use of inferior material, but by stamping, represent it as fine. There are as good and reliable cases made here as in Europe, and no doubt the makers can and will make them as ordered; but there is a great demand for low carat work by dealers, and it must and will be supplied. To this no one could object, were it not for the fraud practiced upon those who have no means of knowing better.

In calculating the worth of a case, the weight and carat must be known in order to arrive at correct valuation; the mere look and feeling is not sufficient. By observing the rules for valuing gold, and a special addition for making, any one may come near the true worth of a case.

It is not proposed here to enter into a detailed list of prices and rates for making cases. In the great variety of styles and materials used, the prices on cases range all along from "a dollar or two" to many dollars. Like the covering—the shell—or case for many other things, a large sum may be lavished upon a watch case as matter of ornament.

For some reason not fully and clearly understood by the author, it costs more, proportionally, to have a case made of gold than of any other material usually used for such purpose. The value of the unavoidable waste, and the extra responsibility in working of gold, may perhaps be considered the chief reasons. It is true, however, that watch cases, owing to greatly increased facilities, are produced much cheaper now than formerly. Good cases, as well as good movements, are at remarkably low prices, and judging from the small amount a base metal or composition case costs, one may justly and correctly infer that cases made out of the precious metals are not as expensive as usually supposed. Case makers, it should be understood, charge more proportionally for a special job—that is, fitting a case to a special movement—than in the regular line of cases for a certain size or kind of movements. In this, like most other manufacturing interests, there is a difference in prices between the regular line of manufacturing new goods and repairing or the doing of a special job. This fact is generally appreciated by those who are familiar with mechanical shops; and any one desiring to learn the cost of a case may be gratified through the trade catalogues; but undoubtedly it is much better to consult a practical watchmaker, and have him supply all wants in that line.

Watch cases are made of various substances. They have been made of shell, leather, horn, and numerous alloys and compounds of metals. Silver is the most common, and gold the most beautiful and costly. Recently they have been introduced made of that wonderful inflammable camphorated gun-cotton patent substance known as celluloid coral; and when well banded or strengthened with metal it makes quite a handsome and durable case.

Cases made of nickel or of some metallic composition and plated with this metal are coming into general use, and answer as well or better than silver. It is not as subject to become stained or discolored by atmospheric influences, or other causes, as the latter metal, and is stiffer and cheaper, making in every particular quite a handsome and durable case. It is said that there are no cases made solid of nickel, but only heavily plated with that metal on some other metallic body; but as the process of working it has been much improved, and as it is coined into money, there appears no reason why it should not be made into solid cases. It is used extensively in the arts as a plating material, and gives general satisfaction.

Many metallic compounds or alloys are and have been used in the making of watch cases since the days of the celebrated "Pinchback," who invented a compound bearing his name, and of which the cases of many English watches were made a great many years ago. It resembled gold very much in appearance, was well calculated to deceive, and hence all cheap yellow-cased watches were considered as Pinchback cheats; but when fire-gilded, as they frequently were, these cases not only looked fine, but were quite durable. Since the days of Pinchback, several other and similar compounds have been introduced under various names, recommended and advertised by "honest" jewelers and dealers as perfect representations of gold, the difference between which, they say, cannot be told even by so-called "experts." These compounds have also been extensively used in the manufacture of jewelry, which is more especially noticed under the head of "Jewelry and jewelers."

In the manufacture of watch cases, as in a great variety of other goods, white or light colored metallic compounds, consisting in various proportions of zinc, tin, nickel, and other light-colored metals, are used extensively under different names. The most noted of these is that known as German silver, invented by a German chemist. By the English it is called "albatta," which means white; and a similar composition is called nickel silver, much used in the manufacture of the best article of silver-plated ware. Another material is called aluminum silver, as also aluminum gold, out of which cases are made represented as being equal to gold. These white compositions in watch cases are usually electro-plated and stamped "sterling silver," which may be true as to the surface, but their true character is soon exposed by use.

Cases made of silver, as before stated, are and have been in more general demand among substantial working people. It being cheaper, and one of the precious metals, it fully comes up to the required standard of fineness and style with a large class of those whose business requires watches for practical usefulness. English silver cases with gold joints in former days often contained very fine movements, sold to those who were able to purchase a fine movement, but were either unable or not disposed to indulge in the luxury of a gold case. Indeed, a heavy silver case, gold jointed, was, as a general rule, understood at sight to indicate a fine movement. Whether for that purpose or for some other reason the joints were made of gold, the author is not fully advised; but the case makers are presumed to have understood the motive. American silver cases weighing three ounces and upward are also for some reason or other most generally gold jointed, which adds only a trifle to the cost of the case, but improves the appearance very much. This of itself is sufficient reason, but the more obvious one may be that gold answers better for such a purpose. Let this, however, be as it may, it is a good suggestion to have as a rule only fine movements placed in gold-jointed silver cases.

In making watch cases of gold, the artisan has before him a vast field in which to display his skill in ornamentation. They may not only be splendidly rich in metallic luster and beauty, but such cases are often seen with the most exquisite designs engraved upon them, in the highest order of art. They are often richly enameled, and are sometimes ornamented with costly gems. Large amounts of money may thus be expended in elaborating upon the work and material used in the production of watch cases. Still, all this expense on the case is not conclusive evidence of the good time-keeping qualities of the inclosed machine, any more than the beauty and costliness of the snuff box assures the good quality of the snuff it contains. As a general rule, the beauty and expense of the one indicates what the other should be; yet very poor "insides" are often covered with respectable-looking cases.

It may be asked, "What is the purpose of a watch case? Is it an article of ornament only? Is it merely a piece of jewelry, or is it specially made to protect the machine it contains, one of man's most wonderful specimens of ingenuity?" While it may be well not to lose sight of the ornamental features the article should possess, yet it must be remembered that it is of prime importance to so construct it as to exclude as far as possible all moisture and dust, which as all watchmakers well know, are the great hinderances to a good performance in time keeping. It should be of sufficient stiffness, also, to protect from injury by external pressure the delicate parts it contains. This is so important that no one who carries a watch for usefulness, and not for ornament, can afford to neglect or overlook it. Light, thin-cased watches may answer as articles of jewelry for women or fancy men, but active working men should look well to the quality of the case that contains their daily companion and guide as a time keeper.

A very handsome, durable, and cheap case is made by the process of stiffening with a base metal. They are made in this country under patents—as, indeed, is almost everything else except babies—suited for and fitted to American movements. They are called "filled cases," and are in every respect for use as good as a solid gold case so long as the plate of gold on the outside lasts, which, if made thick enough to allow of engine turning or engraving without cutting through and exposing the filling, will wear, perhaps, as long as any American movement. If the plate is very thin, as it frequently is, it is no better than a good coat of fire gilt.

The thickness of all plate work can be easily determined unmistakably by cutting with a graver or other suitable tool into some portion of the work through the plate and applying nitric acid in the cut. The acid readily shows the line between the gold covering and the base body, for it never lies, though case makers sometimes do.

This mode of case making is another demonstration of the economy and saving which is generally practiced in the working of gold. This plating process by rolling out sheets of gold "sweated" on to a body of base metal is similar to and of like character with what is called *veneering* in wood work. The cabinet maker, or other worker in fine woods, glues and firmly fixes a suitable board of superior wood upon one of inferior quality, so that when the work is completed and finished up it has the appearance in front of being a solid mass of the former. Fine and expensive wood is thus extended over a much broader surface equally as effective, and therefore more economically worked in that way, than to make it up in solid mass. If worked in solid it is of course very expensive, and answers no better purpose in appearance. Fine woods, like gold and silver, it will be seen, serve to conceal inferior bodies within. Fine covering in many ways tends to make things attractive and cheaper—hence much sought after. And these fine concealing or covering-up substances, whatever their names may be, are always counterfeited and represented in proportion to the popular demand for the article.

It is not, however, very material of what substance a case is made, so far as utility and usefulness are concerned, provided, as before indicated, that the quality and character of the substance and the workmanship are such as to practically secure and save from damaging external influences the machine it is designed to cover and protect, and at the same time afford the necessary facilities for observing its indications. Other considerations in this connection may be classed as belonging under the general head of ornamentation, and, as before stated, furnish a field of vast scope for the exercise of taste, skill, and design.

Case making and repairing are entirely distinct lines of work from those exercised in the making and repairing of movements; and the several parts of cases are produced, like those of the movements, by a great number of operatives, and each one should be specially skilled in his respective department. From the furnace where the metal is melted, mixed, and cast into such shape as desired, it passes on through a series of cutting, rolling, turning, stamping, and finally handicraft completes the case in all its beauty and aptitude of design. Persons wishing to investigate more fully the mechanical operations in the various processes by which cases and movements are produced, are respectfully recommended to visit and carefully look through some or all of the many case and movement manufacturing establishments located in different parts of the country.

The many shapes, styles, and adaptation of cases, and their history, furnish abundant material for a volume, but a short practical notice must serve the present purpose. A treatise on watch cases is necessarily distinct and separate from one pertaining to the movements, as they partake more of the character of jewelry than of the horological branch of the profession or time-keeping department. With this view of the subject before us, the line of distinction is apparent, although it is difficult to treat of one without to some extent touching the other.

When pocket time keepers first came into general use, the cases were made with exposed glass fronts over the face and hands, now distinguished by the term "open face." That was the style in this country as late as fifty years ago, or within the recollection of many persons now living.

That style of case called "hunter's," or "hunting," was invented and introduced to accommodate the demands of Englishmen, whose vigorous and rapid riding in the hunting field necessitated better protection for their pocket timers. In this country a similar necessity arose, particularly among that class whose business required a more substantial guard for their watch. In consequence of breaking the glass, which rendered the watch useless for pocket purposes until replaced, and the long distance very frequently from any place where it could be replaced, the idea was naturally suggested for an entire metallic covering, so that in the event of breakage of the glass inside, the watch could be still used—as though nothing had happened. And as pioneers and hunters of that period, as now, required a watch that could not be broken and rendered useless so easily, they insisted upon a case made in that style; hence, "hunter's," or "hunting" cases. The writer recollects seeing many watches in the glass bezels of which silver plates were fitted in place of a glass. The inconvenience and extra expense of springing the case and the constant liability of breakage in springs always attending the hunting style, have created with many a preference for an open face; and that style of case, with glass of suitable thickness and shape, is the neatest and most convenient. In fact, there is no necessity for one man perhaps in a thousand in this country to have his watch inclosed in an entire outside metallic covering. The open face is undoubtedly, all things considered, the most desirable, and really life is too short to be wasted in opening and closing a hunting case for no useful purpose whatever.

There is a style of case so constructed that it can conveniently be changed from one of the above described styles to the other at the pleasure of the wearer, and hence it is called a "magic case." But owing, it is supposed, to its extra expense and little real usefulness, it has not come into general favor. It is therefore rarely seen, and perhaps is not made at all in this country, and but very few, if any now, in Europe. The author has never seen it of any material but gold. In its construction it was merely a modification of the old "bull's eye," which had a removable outside portion of the case always to be detached or taken off when winding, setting, or opening so as to get a view of the "insides." In the magic case it is only necessary to reverse one portion in another so as to change sides, and the result is open face or hunting, as fancy or notion may dictate.

In the construction and the material used in the making and finishing of watch cases, there is very often much deception practiced: and thereby the means are furnished to enable dealers and traders to perpetrate frauds at pleasure upon those who deal with them. That has always been so from the days of Pinchback cases up to the present time; and it is fairly presumable that it will continue so for all time to come, in some shape or other. It is no fault of those who make the cases, for they, as a rule, either make them to supply a well known and paying demand, or to special orders from those whose business it is to make all possible "perquisites" out of their business transactions. In addition to the poor quality of the gold, if indeed in many instances it can be called gold at all, heavy steel springs and other inside "fillings" are often worked in, and all weighed and counted as gold at so much a pennyweight. This it will be seen is done for the purpose of preserving the weight and at the same time saving in the quantity of gold consumed, thus keeping up appearances. Hunting cases can be in this man

ner so manipulated as to save in gold twenty-five to fifty per cent. from the amount calculated in as gold. The evil effects of this, which may be called one of the "tricks of the trade," may be avoided by purchasing open-face cases, in which there are no concealed springs. As before shown, they are much more convenient, and are sufficiently substantial for all ordinary purposes. There is less chance for deception in the open case, as there is nothing but gold and glass, and it is not likely that any one would attempt to sell exposed glass at the price of gold. The remedy for all such deceptions, and the frauds practiced by the aid of such means, can only be found in a more elevated and practical understanding on the part of that class of customers upon whom these schemes and tricks are usually practiced. How and in what manner to do the one and avoid the other are questions the wise have never been able to practically determine. It is contended by some that the manufacturers should guarantee a certain weight of gold of a specified fineness, so that the purchaser of a case marked "50 dwts. 18 c.," may be sure that he has fifty pennyweights of gold eighteen carats fine That may be very well; but for reasons elsewhere explained, stamps or marks, as have often been demonstrated, are not always reliable safeguards; nor can they be made so under the influences that universally prevail in trade. It has always been a common practice in this country to case cheap imported movements in very low carat gold to order for the benefit of a very numerous class of sharp traders throughout the country. Some of the makers were well known, for instance, the noted "Philadelphia cases," which were generally very low carat, but were sometimes called "40 carat," which means forty parts alloy to one of gold. These facts are notorious; they are common with the American idea of "sharpness," and one would think that long before this everybody understood these common tricks, more especially as public schools are so flourishing. The "ought to do" and "should do" propositions can never change this state of things. Whatever is is right; and gold in all its shades and representations is a co-existing necessity to American fashion and style!

Another scheme for the benefit of peddlers, auctioneers, and sharp traders generally, has been to gild very light silver cases—sometimes stamped "18 c."—which enabled the shrewd trader to pass them for fine imported gold cases, at paying prices. The deception, of course, would be revealed after some little time by the silver appearing on exposed parts, but too late generally for redress.

The gilding and plating of cases are much practiced, serving to give them a good appearance and assist very much in the sale of cheap watches. It preserves the goods while in store from corrosion, but when put to use soon disappears, like a fine "shine" on a pair of boots. In fact, "galvanizing" watch cases and "shining" of boots is very similar in character and usefulness. The one serves the same purpose as the other—that of present neat appearance, and a repetition of jobs to keep it up.

In closing this chapter it is only necessary to add that it has always been considered of the utmost importance to the good and lasting performance of so delicate and much exposed a machine as a pocket timekeeper, to have the case as near proof as possible against external pressure and the intrusion of moisture, dust, or other disturbing influences. This is a desideratum of the highest consideration to any one requiring a reliable companion in the shape of a watch.—*The Watchmaker*.

THE MANUFACTURE OF POWDER.

Down through South Wilkesbarre, out to Ashley, skirting the base of the mountain, with a charming view of the beautiful Wyoming Valley as the ascent is gradually made, then rushing along the edge of a deep ravine, into a little vale, and a delightful ride of about thirty-five minutes over the Lehigh and Susquehanna Railroad has brought you to Laurel Run, the diminutive borough that has sprung up here in the wilderness within the last ten years. And to the eye of the traveler speeding on his journey over the mountain it still seems nothing but a wilderness; but let him alight at the little station, walk to the right a few minutes, and standing on the apex of the mountain gaze at the scene which spreads out as a panorama before him—the valley, dotted with city, towns, and hamlets, with the river winding its way between; then retrace his steps down past the busy hum of machinery and up the other side of a vale made picturesque by moss-covered rocks and rustic fences, and the thought has forced itself upon his mind what a beautiful spot this wilderness is. Here are located the extensive powder mills of General Paul A. Oliver, who has transformed the barren wilderness, with only a bridle path, into a charming place of abode, easy of access by well kept roads.

For every ton of coal that is prepared for the market a quarter of a pound of powder is consumed, and its manufacture is attended with considerable risk and danger from fire and explosions Having devised some machinery for the purpose of obviating this difficulty, General Oliver began to manufacture powder in 1869 further down the mountain, where his mills were first destroyed by fire, and after being again erected were blown to pieces by an explosion of the powder. The site at Laurel Run was then chosen, and in 1872 the mills were again put in operation, and here such improvements have been made in the machinery that the mills are now the most perfect and completely equipped of any in the country, the inventive genius of General Oliver having overcome all obstacles. The works consist of a number of frame and iron buildings, located at such distances from each other as is deemed expedient for safety, and all the various stages of the process of manufacture are conducted in separate buildings, the workmen employed in and about them all wearing either shoes with wooden pegs or rubbers. The product of these mills is mining powder exclusively, the capacity being seven tons daily, and five stationary engines, aggregating 250 horse-power, are required to drive the machinery in the various departments.

The first stage in the process of manufacturing powder here is the pulverizing of the charcoal and grinding of the nitrate of sodium, the basis of this powder, which are thoroughly mixed with the other ingredients by means of an ingenious machine, from where it is carried in wooden boxes about a foot square to the incorporating mills. There are six of these mills, but only one box of the mixture is allowed in a mill at one time, and in passing through a series of rollers the ingredients are completely incorporated and deposited in a small stream on a belt and emptied into boxes, which are then taken to the building containing the press. In passing between two massive rollers this raw powder is pressed into cakes and is carried on a belt to the grainer, which cuts the cakes into small grains, and in running over sieves the dust is separated from the grains and they are deposited in boxes at the end of the machine, the larger grains being carried on a belt back to the press. The green powder in then conveyed to the dry house, located about 200 yards distant, where it is placed on an immense canvas belt and dried by means of hot air passing through coils of pipe under the canvas, the hot air being generated by a large fan and engine in an adjoining building When dry, the grains present a dull, black appearance, and are taken to the glazing department, where after revolving several hours in large wooden drums the friction has given them a bright, glossy appearance, and the powder is then ready to be packed into cans and kegs for the market. The machinery, which General Oliver has covered by letters patent, is the most ingenious ever invented for the purpose, removing much of the danger previously existing in powder manufacturing, and the precautions against explosions and fire are of a superior character, large tanks of water being so arranged that by simply pulling a lever the entire mills can instantly be flooded, besides which a pumping engine and hose is always in readiness for any emergency, and the boiler houses are located at such distances from each other that in no case would both be in danger or the supply of steam fail at any time.

This industry gives employment to about fifty workmen, the larger portion of whom, with their families, live in the little borough of Laurel Run, and despite the seeming danger of their occupation, a happier or more contented community probably does not exist. And with reason; occupying neat and comfortable cottages in one of the most delightfully situated and healthy locations in Pennsylvania, with all the advantages that a generous employer can place at their disposal, their children receiving an education such as other children are seldom given the opportunity to acquire, their lot is indeed an enviable one to other classes of workmen.

The community worship in the little rustic chapel located on the hillside, a short distance above the powder mills, where the Episcopal services are regularly held by Rev. T. L. Banister, the rector in charge. It is built of logs, with the bark unpeeled, in the Gothic style of architecture, with the grounds about it laid out in flower beds and terraces, surrounded by a rustic fence, and is very picturesque. The interior of the chapel presents even a more rustic appearance than its exterior, the upright posts, branching at the top, for supports, the chandeliers devised out of the limbs of trees, the chancel rail of heavier knotted limbs, and the rough logs, all covered with bark and moss, the font constructed of moss-covered rocks, with stained glass windows in the roof shedding a soft light on the Easter decorations, and vines creeping all over the font, chancel rail, and tomb, giving a most beautiful effect. A choir composed of the men and their children greatly add to the charms of worship, and many visitors are attracted by its beauties.

Not far from the chapel is the school house, and the same regard for beauty and comfort has been displayed in its construction. It is a neat little one-story building, with skylights in the roof for additional light and ventilation, cloak and teachers' rooms, and contains the modern school furniture and appliances and a cabinet organ, an open grate fire and nickelplated hanging lamps giving it a cozy and cheerful appearance. About forty scholars, ranging from six to sixteen years in age, principally the children of General Oliver's employes, attend the school, which is admirably conducted by Miss L. M. Stoeckel, an experienced and competent teacher. The school is opened every morning with singing and a lecture by the rector, and besides the regular branches the scholars are taught wax work and music. Some of the scholars are quite proficient in this art, their wax work having been sent to New York and Wilkesbarre and being highly commended for its excellence. General Oliver has secured quite a number of mulberry trees for planting, and within a year the scholars will also be taught silk culture. The pupils are very bright and evidently appreciate the efforts that are being made for their advancement.

The cottages of the workmen, built in the Swiss style, are scattered along the hillside, and standing on a rocky eminence, overlooking the surrounding country, is the summer residence of General Oliver, who can look around and about on what he has accomplished in the past ten years with a pardonable feeling of pride; and as the vast fields of coal in this region yet undeveloped are opened, the demand for his products will be still more increased, and that this same spirit of progress and philanthropy will characterize his future operations is assured.—*Wilkesbarre (Pa.) Record.*

THE MANUFACTURE OF CLOISONNE AT PEKING.

In his report on the trade of Tientsin for the year 1880, Mr. Detring, Commissioner of Customs at that port, says:

The making of cloisonné at Peking and its export from this place is steadily increasing. As the art is quaint and interesting, and the process of manufacture not generally known, a description may find room here of the various processes an ordinary vase has to undergo before it becomes that quaint bit of grotesque coloring which so delights the soul of the *bric-à-brac* hunter. The requisites for its manufacture are a copper vessel beaten out into the required shape, bits of copper wire flattened and bent to form the desired pattern, a kind of glass or silicic substance, great skill, and, above all, consummate patience and plodding perseverance. The flattened copper wires which form the divisions or walls between the various colors are dextrously shaped into curves or leaflets of a given pattern by little boys, who have no other implement than a pair of pincers in each hand. These bits of wire are then grouped upon the surface of the copper vessel to make the outlines of flowers, birds, or arabesques, and temporarily secured with glue. When the whole pattern is complete it is firmly fixed to the background by strewing a quantity of silver filings thereon and exposing it to the sharp heat of a charcoal fire. It is now ready for the filling in of the colored glass, which is crushed and mixed with water, in order to make it adhere to the surface. Each color is carefully filled into its proper compartment by means of a tiny spoon or ladle. The filling in being completed, the whole vessel is entirely surrounded with charcoal fire, until the glass is melted, and then taken out to cool. This process of filling in and burning has to be repeated several times before every cavity is filled to the surface, and once more after the whole has been ground down, if any inequalities are discovered. When a completely equal surface has been thus obtained, it is elaborately polished and the copperwork gilded. But what has taken so short a time to describe takes several weeks to accomplish.

The manufacture of cloisonné had its rise and fall, like everything else. It flourished especially during the King Tai reign of the Ming dynasty, and again during the reigns of Kang Hsi and Kien Lung, of the Ta Ch'ing dynasty. Among the productions of those epochs are to be found many pieces of high art, for which there exists an increasing demand During the reigns of Tao Kwang and Hsien Fêng this industry, like that of porcelain, fell off very much, and during the times of rebellion the art in it got almost extinct. However, since foreigners are residing at Peking, a great demand has gradually been springing up for the article, and much progress made toward conquering for it the admiration bestowed twenty years ago only on the cloisonné produced in days gone by.

ENGLISH UNIVERSITIES.

Abstract of a recent lecture before the students of the Johns Hopkins University, by James Bryce, M.P., D.C.L., Regius Professor of Civil Law in the University of Oxford, England.

"England now has five universities; formerly there were only two. Scotland has four, two having been united. Oxford and Cambridge have existed for many centuries as fully appointed universities. The university of London is not properly a university, but merely an examining body for granting degrees, and it does that kind of work thoroughly. The university of Durham is new and not yet prominent. The new university at Manchester is the outgrowth of Owens College, and was originally endowed, like the Johns Hopkins, by a private founder, afterward by subscriptions. It has become known chiefly by its work in natural science, but desires to encourage humanistic studies equally. We anticipate a great future for it. None of the English or Scotch universities are denominational; none have now (since 1871) religious tests, except that the Established Church in both England and Scotland has possession of the theological faculties. English universities are self-governed, except London and Manchester, which are controlled respectively by a senate (named by the Crown) and by a board of trustees. The constitutions of Oxford and Cambridge are very complicated and are understood by nobody outside the universities and by few inside. Ancient usage, modern Acts of Parliament, and their own legislation have all gone to the making of them. These university governments have two modern assemblies called in Oxford "Convocation" (made up of alumni having degrees) and "Congregation" (made up of graduates resident in the university town). These latter appoint the University Council, and all university statutes must pass through the three bodies.

"In the matter of teaching, the Scotch universities are much like American colleges. The methods are catechetical. Teaching is regarded as more important than examinations. Prizes are in vogue and exercise great influence. In Scotland, prizes are usually awarded by vote of the students. Practically the system works better than would awards by the professors. Prizes generally go where they belong. The Scotch universities are cheap, because the fees are low and the students live where they please. Their conspicuous and distinctive merit lies in the great stimulative power of their teaching. In England there is, with less of this stimulus, perhaps more of finished scholarship and greater opportunities for an enjoyable social life. There are three sets of teachers in the English universities: (1) the professors, who have hitherto taken a part in the teaching more dignified than practically important, except in natural science, where they have had nearly all the work to do. (2) The tutors and lecturers, who bear the burden of practical work and give their instruction in connection with some college independent of the university proper. (3) Private tutors, or 'coaches,' from whom forty years ago came nearly all the instruction at English universities, but who are now much less active, because both university professors and college teachers have become far more efficient than they were then. In England, examinations have become the main thing, and practically control the teaching, although the true view of them would rather be that they should exist as a test of teaching. The examinations, though very old, had become purely formal in the last century: their present importance is comparatively recent. In the Cambridge Triposes, students have heretofore (for a change is now being made) been arranged according to merit. At Oxford the arrangement has been into classes, according to merit, the successful men being arranged alphabetically in each class, so that it is not known, unless the examiners give private information, where a man really stands in the class he has reached. Students are the more ambitious to reach as high a class as possible, because fellowships and success, in such a profession as schoolmastering, depend, to a considerable extent, upon such rank.

"The followships yield from $750 to $1,000 a year. Most of them are at Oxford awarded for proficiency in the same studies as are required at the examinations in the various schools of the university. There is hence difficulty in England in causing students to follow any lecture course or branches of liberal culture which do not count toward their examinations in the schools, or toward a fellowship. Among the practical university problems of the day are: (1) The reduction of expenses for students. The necessary cost at an English university is from $600 to $1,000 a year. (2) The creation of a more complete system of preparation for the leading professions. Something has been done toward the promotion of training for clergymen and for lawyers. Oxford and Cambridge have deficient facilities for medical training, because the towns are too small to support great hospitals. Natural science is now everywhere encouraged. (3) Ampler provision is required for teaching in a great number of more recondite subjects, and encouragement should be given to men, who do not intend to pass through the whole university course, to come and attend lectures in these subjects. (4) Something should be done to enable the university to help original research, and to increase the number of residents who devote themselves to the pursuit of learning. At present large funds are wasted in what are called 'prize-fellowships.' Unfortunately the land revenues of the colleges have suffered from the competition of Western America, and money is wanting to carry out some of the most desirable improvements. Broadly considered, the advantages of English university education may be said to consist in the combination of college and university life. The Scotch universities afford efficient class teaching; the German universities give the fullest instruction by professional lectures; the English universities excel in social advantages and in opportunities for forming valuable friendships. The excessive development of their examination system has certainly injured their teaching; but it has been improving in compass as well as in earnestness, and seems likely to improve still further."—*University Circular*.

Clearing a Tunnel of Smoke.—Good report is given of the great fan lately constructed for the ventilation of the railroad tunnel between the St. Louis bridge and the Union Depot. It is said that the tunnel can be cleared of the smoke of the heaviest freight train in three minutes; and that when no trains are passing the air is as fresh and clear as that outside.

THE INFLUENCE OF MATHEMATICS ON THE PROGRESS OF PHYSICS.*

By PROF. ARTHUR SCHUSTER.

In discussing the value of a given study, a lecturer is by common consent allowed—sometimes even in private duty bound—to exaggerate the importance of his subject, and to present it to his audience enlarged, as it were, through the magnifying power of a projecting lens, so that the details with which he has necessarily to deal may be brought into more prominent view. In an introductory lecture such as it is my duty to give to-day, the speaker need the less feel any scruples in following the usual custom, as different subjects are treated of in successive years, and the hearer may, after the lapse of a short cycle, strike a pretty fair balance between the various branches which have successively been brought before him. But although I might have felt tempted to-day to insist on the advantages of applied mathematics as a separate subject not only worthy of study, but second to none in interest and importance, and though I feel no doubt you would have accorded to me the indulgence which everybody requires who endeavors to lay an abnormal stress on the merits of a single branch of human knowledge, I prefer to found the claims of the subject which I have the honor to represent in this college, not so much on its intrinsic value as on the influence it has had on the progress of other sciences. For no subject can stand by itself, and the utility of each must be measured by the part it takes in the play of the acting and reacting forces which weave together all sciences into a common web.

The growing importance of mathematics as an aid to the study of all sciences is daily becoming more apparent, and it may indeed be questioned whether at the present time we can speak of physics as apart from applied mathematics. Riemann's opinion that a *science* of physics only exists since the invention of differential equations is intelligible; but however close the connection between physics and mathematics may be or may become, their growth in the earlier stages has been altogether independent. Galileo may be said to have been the founder of mathematical physics, and among his successors have been many who showed a greater inclination toward pure mathematics than toward physics proper. On the other hand, we can trace back the ancestry of our experimental physicist and that of our modern popular books on science to the Middle Ages, where we reach J. Baptista Porta and his books on natural magic. Even eighty years ago the fullest account of the state of experimental science was to be found in "Wiegler's Natürliche Magie," a book of twenty volumes, in which scientific experiments and conjurers' tricks are alternately described. But since the beginning of this century the importance of the mathematical treatment of purely physical subjects has steadily grown, and fifty years ago the two sciences were already sufficiently united to induce the founders of the British Association to join them together into one section. From that time until the present year, when the mass of work necessitated a temporary separation, the experimentalist and the pure mathematician could be seen at the annual meetings listening, or at least appearing to listen, to each other's investigations, and the influence which men of science on these occasions had on each other may be taken to represent roughly the mutual influence of the two sciences themselves; it was substantial, though in great part unconscious. I could not attempt to-day to give you a complete historical survey of the effect which the contact—one might often say the collision—of the two sciences had on the progress of each; even that part of the subject which I have chosen for special consideration is too vast to be successfully confined within the limits of a single lecture, and an incomplete sketch is all I can offer.

The influence of mathematical investigations on physical theories is not restricted to any single stage, but makes itself apparent throughout the whole course of their evolution. Before a theory is even started, the mathematician is often necessary to prepare its way. He has to classify complicated facts in a systematic manner, and working backward from the phenomena presented by nature, he endeavors to find out which of them are necessary consequences of others, and which of them require independent hypotheses for their explanation. It is in this way that the works of Poisson, Green, Gauss, and of all those who have followed in their footsteps, may be said to have laid the foundation of the theory of magnetism and electricity, although we do not as yet possess any physical notions as to the causes of these phenomena. The true power of mathematics, however, comes into play only when the physical inventor has done his work, and has formed distinct materialistic conceptions which allow themselves to be expressed by mathematical symbols. It is then that the consequences of the theory are to be worked out and tested by experiment. In order to be convinced of the truth of any hypothesis, the scientific world wants quantitative experiments. Numbers form the connecting link between theory and verification, and they always imply mathematical formulæ, however simple these may be. Often two rival theories are on their trial and the mathematician is supposed to find out where their conclusions differ and where crucial experiments are most likely to decide definitely between them. It is remarkable, however, how much more often physical or even metaphysical considerations have decided between two theories than arguments derived from mathematical reasoning. So called crucial experiments, as a rule, come either too early or too late. Sir Humphry Davy's experiment was absolutely conclusive against the corpuscular theory of heat, but scientific ideas were not ripe yet for the discovery, and his experiment had no marked effect on the progress of science. The crucial experiment here did not involve any mathematical deductions; it is otherwise with that which might have decided between the two theories of light. According to the corpuscular theory, light travels more quickly in water than in air; according to the undulatory theory, the passage through water is the slower, and this distinction is founded on the necessity to account mathematically for the laws of refraction. But when Foucault actually made the experiment, and gave a death-blow to the corpuscular theory, that theory was already dead. There was then only one scientific man of note left who still viewed the undulatory theory with suspicion, and his suspicions were not allayed by the crucial experiment. But if mathematical deductions have not decided as often as they might have done between two rival theories, they have constantly strengthened and confirmed our belief in physical hypotheses by inventing new cases which might test the theory, and which might, if experiment supported the mathematical deduction, establish it on a yet firmer basis.

* A lecture introductory to the Session, 1881–82, of Owens College, Manchester, by Arthur Schuster, Ph.D., F.R.S., Professor of Applied Mathematics.

The most important of all the functions of mathematical physics, however, and perhaps the only one through which mathematics has had unmitigated beneficial influence on the progress of physics, is derived from its power to work out to their last consequences the assumptions and hypotheses of the experimentalist. All our theories are necessarily incomplete, for they must be general in order to avoid insurmountable difficulties. It is for the mathematician to find out how far experimental confirmation can be pushed, and where the new hypothesis is necessary. Facts apparently unconnected are found to have their origin in a common source, and often only a mathematician can trace their connection. It is here that the pure experimentalist most often fails. A new experiment gives results to him unexpected, and he is tempted to invent a new theory to account for a fact which may only be a remote consequence of a long-established truth. Many examples might be given to show how mathematics often finds a connection unsuspected by the pure experimentalist, but one may be sufficient. A ray of light passing through heavy glass placed in a magnetic field, in the direction of the lines of force, is doubly refracted as it comes out. To none but a mathematician is it clear that this is only a direct consequence of Faraday's discovery that the magnet turns the plane of polarization of the ray on its passage through the glass. Happily this fact was first worked out theoretically; had it been otherwise, we should have heard much of the power of the magnet to produce double refraction.

In addition to the many services actually rendered by mathematical treatment, the mere attempt to put physical theories into a form fit for such a treatment has often been invaluable in clearing the theory of all unnecessary appendages, and presenting it in the simple purity which may bring its hidden failings to light, or may suggest valuable generalizations. Instead of dealing, however, in a general manner with the various ways in which mathematics have been useful in the prosecution of physical investigations, it will be better to give a short account of the growth of some of our physical theories, and to illustrate the subject of this discourse by a few digressions suggested by the historical development.

As a first example I chose the progress of the undulatory theory of light. There is no other branch of physics in which the power of mathematics has been more successfully shown, nor is there one which shows the relations of experimental to mathematical physics in a truer light. At first we had experimental facts ahead of theoretical explanations; then we had the undulatory theory, which placed theory in advance of experiment; and now again a reversal has taken place, and unexplained experiments will remain unexplained until we shall be able to form more definite ideas of the relations between matter and the luminiferous ether.

Huyghens first worked out scientifically the hypothesis that light consisted of the undulations of an all-pervading medium. But as those who adopted the rival theory professed to explain equally well all phenomena which were then generally known, the scientific world preferred to walk in Newton's footsteps, and to reject what they believed to be the complicated and unnecessary assumption of a universal medium. The corpuscular theory could easily explain the ordinary laws of reflection and refraction. Its attempts to explain the colors of thin plates and the fringes of shadows were less successful, but experimental investigations of these phenomena were not sufficiently advanced to bring these facts prominently into view, nor had their true explanation as yet been given. It was only when mathematical analysis was applied to the undulatory theory that its enormous advantages were discovered. Neither of the men to whom we owe the greatest advance which has yet been made in the science of light was a professed mathematician. Young was a medical man; Fresnel was an engineer; nor was the subject, when these men took it up, in a state which would have attracted a mathematician. Conceptions distinctly physical had to be formed, and assumptions not quite satisfactory had to be made. Their chief claim to our gratitude rests, not so much on the mathematical treatment they have given, as on the fact that they left the subject in a state sufficiently advanced to allow mathematicians, even without special physical proclivities, to take it up, extend it, and establish its foundations more firmly than otherwise they could have done.

The different manners in which Young and Fresnel set to work to prove to the scientific world the truth of their favorite hypothesis, and the corresponding difference in their success, is especially interesting for the purpose which we had in view. Both men had considerable mathematical ability, and of the two, Young perhaps had the greater inclination toward pure mathematics, yet he avoided wherever he could the use of mathematical symbols, and disdained to bring forward experimental verification for what he considered sufficiently clear without.* It is to Young that we owe most of the physical conceptions which have secured a final success for the undulatory theory of light. He was the first to explain the principle of interference both of sound and of light, and he was the first to bring forward the idea of transverse vibrations of the undulations of light. The most diverse phenomena were explained by him, but their easy explanation was a sufficient proof to him of the theory he was defending, and he did not trouble to verify his conclusions by extensive numerical calculations. It thus happened that, although Young was first in the field in furnishing the true explanation of complicated phenomena, Fresnel, applying mathematical analysis to a much greater extent, had a much more potent influence in turning the scale of public opinion in favor of their common theory.

Though Fresnel's first memoir was published fourteen years after Young had established the principle of interference, Young's writings had remained unnoticed by him as well as by the scientific world in general, and Fresnel was surprised and irritated to hear that another had been in the field before him. But every one must agree that the chief share in securing the final triumph of the wave theory belongs to Fresnel, nor can there be any doubt that this is due to the mathematical calculations which he applied to cases easily verified by experiment. For there is a great fascination in a table with one column headed "calculated," another headed "observed," and a third giving the differences with the decimal point as much to the left as possible. And it is right that such tables should play an important part in the history of science, for whatever the ultimate fate of a partially accepted theory, the one solid legacy which it will leave behind after its death is the array of numbers for which in its successful stage it has given a sufficiently correct account.

Fresnel invented different pieces of apparatus to test Young's simple supposition, independently made by him, that waves may be made mutually to destroy one another by addition, the crest of one wave being superposed on the hollow of another. It is necessary that the waves should originally be derived from a single source of light, yet they must seem to diverge from two different points. The necessary experimental conditions were fulfilled by the ingenious device of reflecting the light from two mirrors slightly inclined to each other. The light diverging from the two images of one source was allowed to cross, and bands alternately luminous and dark were measured at the places where the waves overlapped. A rough micrometer of his own construction served to measure the intervals between the bands at various distances from the mirror, and Fresnel succeeded in obtaining sufficient data to test his theory. It cannot be my purpose to follow Fresnel and to describe all the various devices which he invented to confirm his views, and to establish the true theory of diffraction. Though he succeeded in making a convert of Arago, the greatest authorities then living, and the most influential men in scientific matters, both Laplace and Poisson, disdained to consider the theory. The mathematical basis on which the theory rested seemed to them to be weak and insufficient. No doubt they were right; for many assumptions made by Fresnel were daring, and only justified by the results of further more careful investigations; some of his assumptions even were inaccurate. It was only when the phenomena of polarization and double refraction were explained that Laplace acknowledged the great power of the undulatory theory, and with a remarkable inconsistency publicly stated his admiration for Fresnel's work, after a paper which is more unsatisfactory from a mathematical point of view than anything else written by Fresnel. The opposition to the undulatory theory offered by the strictly mathematical school, no doubt prevented its rapid acceptance by the general body of scientific men, but it is doubtful whether its final success was delayed. On the contrary, Fresnel was spurred on to greater exertions, and the excitement caused by the violent views taken by the opposed parties, rendered the question a burning one, which it was necessary to settle definitely. The impartial observers had, at the time of which we are speaking, one strong argument for suspending their judgment. One great class of phenomena, now known under the title of phenomena of polarization, were unexplained as yet, and it seemed doubtful to them whether the undulatory theory could successfully overcome the difficulty. Then, as before, it was Young who first gave the physical explanation, while it was reserved for Fresnel again to show how the explanation was sufficient to account numerically for all the observed facts.

Those who first started the idea of luminous undulations founded their belief in great part on the analogy between the phenomena of light and those of sound. In a wave of sound each particle moves in the direction in which the waves are propagated, and it was natural to make the same supposition for the waves of light. Yet the mass of unexplained facts forced Young to consider the alternative case of waves in which the motion is in a plane at right angles to the direction of propagation. The waves of water in which such a motion partly takes place may have given to Young the first idea of a supposition which, as he showed, could account for many apparently singular phenomena. But his want of taste for calculations, as well as for experimental verification, prevented him from reaping the full fruits of his fertile ideas. Fresnel tells us that when he first conceived independently the idea of transverse vibrations, he considered the supposition so contrary to received ideas on the nature of vibrations of elastic fluids, that he hesitated to adopt it, and he adds: "Mr. Young, more bold in his conjectures, and less confiding in the views of geometers, published it before me, though he perhaps thought it after me." But when once the question was raised, Fresnel applied to it the patient skill which, either by strict mathematical deductions, or by happy guesses and assumptions, surmounted all difficulties. The phenomena of double refraction, and their connection with polarization, were now explained, and all the varied phenomena of light seemed naturally to follow from the simple supposition of waves of transverse vibrations. Such a successful application of mathematical calculations to the investigation of physical phenomena had not been heard of since the time of Newton, and could not fail in the end to produce its due effect. The supporters of Young and Fresnel became more numerous and confident, and the scientific societies duly acknowledged the services rendered by both. Young was elected one of the eight foreign members of the French Academy, and Fresnel received the Rumford Medal of the Royal Society, which, however, only reached him on his death-bed.

The undulatory theory now entered on a stage in which it could be taken up by the mathematician pure and simple. Its foundations had to be rendered more secure, and its consequences had to be worked out to a greater extent than even Fresnel had done.

The scruples which hindered most of the French mathematicians from accepting Fresnel's views were shared by Poisson, who deduced from his equations a result apparently paradoxical. According to Fresnel's formulæ, the center of the shadow of a small circular disk formed by a luminous point should be as bright as if the disk were absent. But however curious this result might be, it had been observed just 100 years before Fresnel's time, and as that experiment had been completely forgotten, Poisson's theoretical conclusion had again to be subjected to the test of experiment, when it was found to be completely in accordance with fact.

But the most remarkable discovery made solely by calculation was the so called conical refraction, theoretically deduced from Fresnel's wave surface by Sir Wm. Hamilton. That great mathematician had found that a point, when looked at through a crystalline plate cut in a certain direction, should appear not as a point, but as a ring, and the fact was verified experimentally by Prof. Lloyd. This discovery has always been considered one of the greatest triumphs of mathematical physics, and justly ranks on equal terms with the discovery of the planet Neptune by Adams and Leverrier. It is necessary to remark, however, that strange and unexpected conclusions, especially when they have been arrived at after complicated mathematical transformations, tempt us sometimes to exaggerate the additional support which their verification gives to the theory by means of which those conclusions have been reached. It is extremely unlikely that any theory should account for all the facts explained by Fresnel, and not also for all those discovered by his successors. As a matter of fact, Fresnel's wave surface is not the only one which has been suggested, but as they all contain the singular points at which the conical refraction is produced, this phenomenon is no proof that Fresnel's equations are strictly correct. It often happens in mathematical explanations of physical phenomena that the equations originally deduced contain a series of con-

* "For my part it is my pride and pleasure, so far as I am able, to supersede the necessity of experiments."—Peacock's "Life of Young," p. 477. Abstract of letter by Young.

stants which are then determined to fit the experiments. This process, which is perfectly legitimate, does, however, often prove only that the theory is successful in giving us a useful formula of interpolation, and need not be conclusive in favor of the ideas which have led to the formula. In a considerable number of cases, such as the reflection of light from metals, and even the theory of double refraction, we have different formulæ which all give, as far as we can test them, a sufficiently correct account of the facts, and none of them therefore prove anything in favor of the views which the different authors of the equations have put forward.

Before leaving our consideration of the services rendered by mathematics to the undulatory theory, we must not forget to notice the mathematical investigations by means of which its foundations have been placed on a safe dynamical basis. The investigations of Cauchy, those of Green, which followed, but especially those of Stokes, have secured for this theory such a firm support that even Laplace might have accepted it without further scruples. As a matter of history these investigations have done little toward the final victory of the theory. They came too late to affect the course of events, but they have increased the confidence of mathematicians in physical theories, and have prepared the way for further investigations.

As I have already remarked, it is one of the great objects of mathematical physics to investigate how far we can safely push certain assumptions and where a new hypothesis must be brought into play. And, indeed, when we have carried our calculations as far as we can, when we have experimented and measured as much as we can, we find that the undulatory theory as it stands at present, though following up to a certain point with marvelous accuracy the true course of nature, shares the common fate of all theories, and leaves a vast quantity of facts unexplained and waiting for more complete investigations Nor is this to be wondered at; our assumptions as regards material media may in many cases give correct results, and no doubt answer very well as a first approximation, but we arrive at a point where such a material medium can no longer be considered homogeneous, and here our conclusions must break down; but it is to mathematics that we must look for the next great step. The progress of the science of optics during this century has shown us how much mathematical calculation can help to establish a great and important fact such as the existence of that all-pervading medium, the vibrations of which constitute light, and I may review more quickly the recent progress of other branches of science.

In the science of heat we do not require mathematical calculations to show the superiority of the mechanical over the corpuscular theory. Sir Humphry Davy's experiment shows conclusively that heat cannot be a substance, and Joule's experiments served further to illustrate the great advantages of the mechanical theory. The mathematical treatment of thermic problems was not required to establish a theory, but was suggested by practical considerations. The important question, how much work we can get out of a steam-engine, first attracted mathematicians, and out of this question the present science of thermodynamics may be said to have arisen.* Carnot, who gave the initial impulse to these mathematical investigations, assumed in his papers that heat was indestructible, though he seemed personally inclined to prefer the mechanical theory, which denied that indestructibility. Carnot's investigations were only gradually appreciated, and it was only when Clausius and Thomson corrected his theory so as to bring it into accordance with modern ideas, that general attention was directed to the subject. It was found that so many important consequences of physical interest (as the lowering of the freezing point of water by pressure) followed out of Carnot's corrected reasoning that the mechanical theory now rapidly made its way, and though, as already mentioned, the proof of its truth rests on a perfectly simple experiment, mathematics must be considered to have had an important share in the final establishment of that theory.

It seems impossible to speak of the services rendered by mathematics to the progress of our knowledge of heat without mentioning the great law of the dissipation of energy. No two sciences seem further apart than mathematics and metaphysics, yet mathematical propositions have often furnished material for metaphysical speculations on the workings of nature. Thus the many dynamical propositions involving minimum or maximum properties, such as the principle of least action, have been taken to show that nature always works with the least expenditure of force, and thus the important law of dissipation of energy, which asserts that the world must have a slow and gradual end, could not fail to be used in the discussion of its sudden and abrupt beginning. These metaphysical speculations react again on the progress of physics, but it seems doubtful how far this indirect influence of mathematics has been beneficial; at any rate mathematicians cannot be held responsible for such an extension of their power.

An offshoot of the mechanical theory of heat is the molecular theory of gases. The idea on which that theory is based is not new, but it remained a speculation merely until, chiefly through the labors of Joule, the mechanical theory of heat was experimentally established, and its laws investigated. There is, perhaps, no branch of science in which mathematics has had such unexpected results in forming and confirming our faith in purely physical conceptions. That matter is made up of atoms and molecules is a hypothesis which simplifies many physical and chemical problems. It may, on chemical grounds especially, be considered a highly probable hypothesis, but we could hardly have obtained the confirmation amounting to proof which the idea has received of late years, without the mathematical treatment which it has received at the hands of Clerk Maxwell and those who have followed in his footsteps. One of the most astonishing results obtained by Maxwell is the one subsequently verified by experiment, that so long as Boyle's law is true, the coefficient of viscosity, as well as that of the thermal conductivity in a gas, is independent of the pressure. This fact alone, which could never have been obtained without the aid of mathematics, is a sufficiently strong foundation on which we may rest our belief in molecules. It would be extremely interesting to follow out the more recent developments of the mechanical theory of gases, and to show how both mathematics and the absence of mathematics have advanced its progress, but if it is a good rule to say nothing but good of the dead, it is a better one to say nothing at all of the living.

I have already alluded to the mathematical treatment of electricity and magnetism. The aid of mathematics here was not required to confirm a theory, but rather to prepare the way for one. The complicated laws, regulating the attractions of electric and magnetic bodies, and of bodies carrying electric currents, have by the aid of mathematics been reduced to their simplest form, and electrical units have been connected with the ordinary mechanical units. This interesting branch of physics will furnish us with an example of the services which mathematics has rendered in directing the efforts of experimenters into the proper groove. We need only compare the magnetic measurements which were made during the last century with those made in our own time. While the early investigations gave us only a series of numbers impossible to interpret without a large quantity of accessory data, which are generally omitted, modern measurements, even when made by non-mathematicians, have generally been suggested by mathematical calculations and very often serve a useful purpose.

* Foucault's investigations, though of enormous mathematical importance, cannot be said to have had a direct influence on the progress of physics.

I have hardly alluded, as yet, to the science of dynamics, which is the foundation of all applications of mathematics. Its progress has been steady since the time of Galileo, but all the marvelous results arrived at by Newton and his followers—results which first showed the great fertility of applied mathematics—are too familiar to need any enumeration from me. The modern researches in hydrodynamics may perhaps not as yet have led to any definite result of physical interest, but they are rapidly progressing toward that end, and we may look forward to an increasing number of physical discoveries made by the aid of mathematics.

In tracing the history of some of our modern theories, I have followed the usual plan of presenting the history of science as illustrated by the discoveries of our great scientific men. It is necessary, however, to draw attention to the fact, and I have tried to keep this point in view throughout this discourse, that it is not always the most conclusive arguments which carry the day, and that second-hand thinkers have often had a more potent influence in shaping the course of scientific history than those to whom we now justly ascribe the greater merit of discovery. In our historical studies, therefore, we ought to direct our attention not less to that which has influenced public opinion, than to the actual soundness and originality of each discoverer.

If we ransack old books of science we often come across passages of long-forgotten writings, in which, when they are properly construed, when new meanings are given to old words and obscure expressions are freely translated, we may trace a faint prophetic glimmering of a modern theory. Such passages have a peculiar charm for the student of scientific history; they are often the only reward for much patient and otherwise useless reading, and are interesting as showing the almost boundless ingenuity both of him who made the statement and of him who interpreted its meaning. But those who are fond of this process of exhumation ought not to forget that two parties are necessary to every advance in science—the one that makes it and the one that believes in it, and the course of history is as much affected by the second class as by the first.

"A jest's prosperity lies in the ear
Of him that hears it, never in the tongue
Of him that makes it."

A scientific man, in so far as he influences the progress of science, cannot be far ahead of his time, and though his writings may be read and admired centuries after his death, he will have written in vain if he has not been appreciated by his contemporaries or by those who immediately followed them. For our present purpose, then, we must consider not so much those mathematical arguments which appear now to us the most conclusive ones, but such as did appear conclusive to those whose opinion they were meant to affect. But if we try to discover what arguments have had the greatest power in removing old prejudices and in causing a solid advance in science, we find that they have often been of the most flimsy nature. Analogies, sometimes not even good ones, have succeeded where solid reasoning has failed, prejudices have been overcome only by other prejudices, and a rough illustration of a point of secondary importance may have made a previously obscure theory look more familiar, though not more clear, to the popular mind. What, for instance, has the existence of Jupiter's four satellites to do with the question whether the earth turns round the sun or the sun round the earth? Yet the discovery of these satellites has produced a greater revolution in favor of the Copernican theory than anything else that Galileo wrote on the subject.

If we look at the history of science from the point of view suggested by these considerations, we find that in addition to the legitimate influence of mathematics which we have traced, its practical effects, through less reasonable causes, have often been as powerful. The statement that in science authority is of no avail against argument, is one the proof of which must be looked for in the future, rather than in the past. There can be little doubt that authority has had a great effect in all scientific revolutions, and the authority of mathematicians was always greater than that of other men of science. Men are thoroughly convinced in one of two ways only; either by a train of reasoning which they can fully appreciate, or by one which is entirely above their comprehension. To those who are particularly amenable to the second kind of proof, mathematics has always been a magic power. Many results first obtained by the help of advanced mathematics have since been deduced by more elementary reasoning, but it seems questionable whether the original author would have been as successful in overcoming the inertia of his contemporaries, if he had confined himself to language intelligible to the greater number of his readers. It is, no doubt, due to this cause that mathematical papers have brought with them more widespread convincing power than we should now feel inclined to accord to them. The papers of Young, in which he avoided mathematical symbols, may appear to us sufficient to establish the undulatory theory of light; the arguments of Sir Humphry Davy, the experiments of Joule, may seem absolutely conclusive in favor of the mechanical theory of heat; but although the mathematical investigations of Fresnel, Clausius, and Thomson could be appreciated only by a much smaller number of readers, they had a more powerful influence in turning the scale of public opinion in favor of the modern ideas. It seems sometimes almost as if it required an experimentalist to convince a mathematician, and a mathematician to convince the general world. It is impossible to enter into greater detail or to exemplify more amply the assertions which I have made without touching on delicate and controversial matters, but on the present occasion it seemed to me to be specially fitting to point out that the course of science is as much affected by the appreciative faculty of receptive minds as by the creative faculty of the discoverer.

It is given to few only to take an active and successful part in the production of scientific work. The young man who begins life with the idea of making a name as a scientific discover is like the little girl in *Punch* who intended to become a professional beauty. They may both be successful, but if so, it will depend as much on the ready appreciation of their contemporaries as on themselves. The advance of science takes place through many channels, and each generation has its own part to play. Particular ideas, particular faculties are wanted at particular times, and no one can foretell where success will be. Men who are now quoted as shining lights would have passed away unnoticed had they lived at other times, and many a life has been one of patient but unsuccessful work, because its energies were devoted to a subject which was barren, or at least lay fallow for a time. No one, for instance, who has attempted to read through J. B. Morinus's work (and I doubt whether any one has ever got beyond the attempt) can fail to notice in him qualities which might have made a successful discoverer. In his method of determining longitudes by lunar distances Morinus has left us a lasting legacy. During the greater part of his life, however, his energies were devoted to the study and application of astrology, and all the labor spent on that subject was thrown away, although he did his best to make his own prophecies come true, and, having predicted the end of the world for a certain year, went through with his share of the proceedings, and died a natural death at the appointed time. *A priori*, there was no reason why astrology when married to mathematics should not have produced a healthy progeny, and looking especially to the state of science at the time, we can have little fault to find with the old astrologers.

History then does not teach us any royal road to success. But more important for the ultimate progress of truth than a solitary success is the training of the faculty which enables the scientific man to judge correctly, and to appreciate the results of those who strike out new roads and extend the boundaries of knowledge. It seems to me to be one of the chief objects of an institution like this to bring up men, who, by conscientious consideration of scientific speculations, may help to give that solidity and elasticity to public opinion which is necessary for the rapid advance of science.

PHOTOGRAPHIC NOTES.

In the *Mittheilungen* there is an article, by Herr A. Stosch, upon the sensitizing of gelatine plates with caustic potash. He says:

When gelatine emulsion plates are rendered extremely sensitive by being dipped into an ammoniacal and alcoholic silver solution, such as I described in the *Photo. Mittheilungen* (No. 207, p. 70), the silver salt does not work in every case as a sensitizer only through its power of seizing bromine, but it also effects the extremely powerful alkaline reaction of the oxide of silver and ammonia. The omission of the ammonia from the formula, as has been recommended, I consider no improvement, any more than the addition of citric acid, with which I have not succeeded in making *permanent* plates with simultaneous shortening of the exposure. Jastrczembsky's observation that placing the emulsion in a bath of monocarbonate of soda has a favorable action upon the sensitiveness of the emulsion plates, led me to substitute *caustic potash* in *alcoholic* solution for oxide of silver and ammonia, and the result was very good. I have dissolved one and a-half, two and a-half, and even three grammes of *potassium causticum siccum* in 100 c. c. alcohol (of about 87° to 90°), placed gelatine plates in it for three or four minutes, and then dried them in a rather warm room (which, when the room is not too cold, or the atmosphere too much loaded with moisture, should not take much longer than four or five minutes, but the drying must be thorough, else the alcohol will have a harmful effect), after which the plates were exposed. The results exceeded my expectations. Besides an extraordinary shortening (to one-fourth) of the exposure the plates were very clean. The caustic alcoholic alkali saponified cold every trace of grease which was upon the gelatine film, and I consider grease the cause of most of the spots in gelatine plates. During the development the quantity of the alkali upon the gelatine plates is disagreeable. In the first place it leads to fog, and in the second it has a considerable tendency to crêpiness. I therefore place the plates once more in a bath of alcohol before development and after exposure, and overcome the crêpiness by a bath of common salt, in which the plates are placed after the development, and when taken out of it they are at once, without being rinsed, fixed as recommended by Dr. Vogel for such cases. I developed with a liberal quantity of ferrous oxalate and covered the plate well with it, so that the aqueous fluid was not repelled. This process has the advantage over the alcoholic ammonia and silver bath of the unpleasant reaction of the silver upon the gelatine being avoided; and it seems to me that if the alkali be very carefully washed off before development (I have not tried weak acid) the quantity of caustic potash may be increased with advantage. In order to accelerate the drying of the plates after the alcoholic bath it is also permissible to add a little ether, freshly distilled over calcium, to the alcohol. I do not recommend the addition of ether which has already stood some time, particularly if it has stood in bottles not perfectly full and exposed to the light. When trying the foregoing procedure attention must be given to seeing that the plate is thoroughly dry, otherwise it may happen that at those places where alcohol still remains there will either be no image at all or that it may be eaten away.

Herr Prümm gives the following process for reducing a gelatine negative: Lay the plate alternately three or four seconds—first in a fifteen per cent. solution of iron chloride and then in hyposulphite of soda. By alternating these two baths the picture may at last be made to disappear, only a strong relief remaining. It has been recommended to mix the two solutions, but Dr. Vogel points out that the mixture is hardly advisable, as sulphur is thereby precipitated.

Herr Ladewig gives the following as Herr Angerer's formulæ for developer for gelatine plates:

I.

Potassic oxalate	200 grammes.
Distilled water	1,000 "

II.

Ferrous sulphate	100 grammes.
Sulphate of iron and ammonia	100 "
Distilled water	600 "

III.

Gelatine	3 grammes.
Distilled water	400 "
Glacial acetic acid	30 "
Bromide of potassium	5 "
Distilled water	75 "
Alcohol, 40 per cent.	75 "

(Mix equal parts of these two solutions.)

IV.

Hyposulpite of soda	1 : 200

To use, mix four parts of solution I. and one part of solution II.; and to every 100 grammes of the mixture add six to eight drops of solution III. and three to four drops of solution IV.

STORAGE OF ELECTRICITY.

A commission consisting of MM. Allard, L. Leblanc, Joubert, Potier, and Tresca, experimented upon Faure's battery in Paris, January, 1882. The Faure battery was composed of 35 elements, the lead plates of spiral form weighing each, with included liquid, 43·700 kg. The lead electrodes were covered with minium to the amount of 10 kg. per square meter. The liquid consisted of distilled water with the addition of one-tenth of its weight of pure sulphuric acid. The charging machine was of the Siemens type, the armature having a resistance of 0·27 ohm, and the inductor 19·45 ohms. The current of discharge was passed through a series of Maxim's incandescent lamps. The authors state, in general, that they obtained the light of one carcel with an expenditure of 5·80 kgm. of electrical work per second. They were also led to the conclusion that it is advantageous to charge the battery with the feeblest current possible, and to prolong the duration of the charge. The results of the investigation are summed up as follows: The charge of the battery demanded a total mechanical work equivalent to 1·558 horse-power during 22 h. 45 m., or 1-horse power during 35 h. 26 m. The battery received in reality only 0·66 of this work, the rest having been dissipated in the work of excitation.

The exterior electrical work during the entire duration of the discharge amounted to 38,090,000 kgm.; the mechanical work consumed was 9,570,000 kgm., but of this amount furnished only 6332000 kgm. was retained by the battery. Hence the amount recovered during the discharge was 0·40 of the total work, and 0·60 of the stored-up work. The employment therefore of the accumulator has cost 0·40 of the work furnished by the dynamo-electric machine which might have been utilized in other ways. The advantages of having a reservoir of electricity, however, compensate for this loss of energy.—*Comptes Rendus.*

DISCHARGE OF ELECTRICITY BY HEAT.

At a recent meeting of the Physical Society, London, Prof. F. Guthrie, F.R.S., read a paper "On the Discharge of Electricity by Heat." This was concerned with additional experiments to those made by the author on the subject nine years ago. He showed by means of a gold leaf electroscope that a red-hot iron ball, when highly heated, would neither discharge the positive prime conductor of a glass electrical machine nor the negative one; but on cooling the ball a temperature was found at which the ball discharged the negative conductor, but not the positive one. Lastly, on cooling the ball still further (but not below a glowing temperature), it was found to discharge both positive and negative electricity. A platinum wire rendered red hot by an electric current also discharged a negatively charged electroscope more readily than a positively charged one. When placed between two electroscopes, one having a + and the other a — charge, it discharged neither. When the + one was withdrawn the — was discharged; but when the — was withdrawn the + was not discharged. There therefore seemed a tendency in a hot body to throw out + rather more than — electricity. That a material medium between the heated body and the electrified one was necessary, was shown by the failure of the experiment with a Maxim incandescent lamp consisting of a carbon filament in a vacuous bulb. Dr. Guthrie also showed the demagnetization of a small magnet in the heat of a Bunsen flame by inserting it in a coil of wire connected to a mirror galvanometer, and heating it in the flame. He also showed that the pole of a voltaic battery could be discharged by heating it red hot. This was done by connecting a piece of fine platinum wire to one pole and heating it in the flame of a spirit-lamp, care being taken to insulate the lamp to prevent conduction to earth. The discharge was shown by means of a mirror electrometer.

WHY WE COUGH AND HOW WE COUGH.

Everybody coughs sometimes, and, judging by the quantity of patent cough medicines sold, many people must be coughing all the time. Most persons suppose that a cough is a cough, the world over, and what will cure one will cure another; and so they prescribe for themselves and their friends all sorts of sirups, home made or proprietary, with the consoling assertion that "it can't do any hurt if it don't do any good." How do you know it can't do any hurt? Do you know its ingredients, and, if so, have you studied their effects upon the system in health and in disease? Do you know the condition of the patient you are prescribing this for—his constitution, his habits of life, his past history?

Let us see what a cough is. It is a sudden and forcible expulsion of the air from the lungs, preceded by a temporary closure of the wind-pipe to give additional impulse to the current of air. The effect of these spasmodic expirations is the removal of whatever may have accumulated in the air-tubes, whether a foreign body from without, as when a particle of food finds its way into the wind-pipe, or an accumulation of mucus secreted by the air passages themselves.

Coughing is in part a voluntary act. We can cough whenever we wish to, but frequently we are compelled to cough when we don't wish to. Nerves are divided into two classes, sensory and motor nerves. The former carry intelligence to the brain; they report any disturbance on the frontier to headquarters. The motor nerves then carry back the commands of the general to act. You tickle a friend's ear with a straw, and his hand automatically proceeds to scratch the itching member. A tickling sensation is produced in the throat by any cause whatever; the brain then sends back orders to the muscles concerned to act so as to expel the intruder, in other words to cough. And that is how we cough.

The source of the impression may be various. Frequently it is due to an irritation of the respiratory organs by foreign bodies, dust, and acrid vapors, admitted with the air in health, or to damp, cold air itself, if the organs are particularly sensitive, or to the presence of mucus, pus, or blood, in disease. Inflammation, from whatever cause, acts as a source of uneasiness.

There are, as we all know, many different kinds of cough. Thus we have the dry cough without expectoration, and the moist cough with expectoration. We have the short, hacking cough, resulting from slight irritation, and the violent, spasmodic, and convulsive cough, caused by a greater degree of irritation or some peculiar modification thereof. Then there are the occasional, the incessant, and the paroxysmal cough, terms that explain themselves. Hoarse, wheezing barking, and shrill coughs are due to the tension or capacity of the rim of the wind-pipe or other portion of the tube. The hollow cough owes its peculiar sound to resonance in the enlarged tubes or the cavities in the lungs, if such exist. Sometimes the exciting cause of a cough lies not in the lungs and respiratory organs, but in the stomach, liver, or intestines. In other cases there seems to be no real cause; it is purely nervous or hysterical.

Cough remedies should be suited to the kind of cough in question, and attempt, if possible, to remove the cause. It is evident that a cough may be lessened either by removing the source of irritation, or by diminishing the excitability of the nervous mechanism through which it works. Both methods are generally employed, and most of the popular cough medicines consist of an expectorant and a sedative, in some mucilaginous or saccharine menstruum. Sedatives lessen the excitability of the nerve center through which the act of couching is produced. Opium in sufficient quantities will stop any cough, but if the secretion goes on accumulating, the patient must be allowed to cough, or he dies of suffocation.

Glutinous and saccharine substances lessen irritation, and as it frequently happens that much of the irritation which occasions the cough exists at the root of the tongue, and in portions of the throat which can be reached by troches and lozenges slowly dissolved in the mouth; hence these often afford relief, especially in dry, hacking coughs and the so-called tickling in the throat. Iceland moss, marshmallow, and gum arabic belong to this class. Their power is probably due to their covering the inflamed and irritable surface directly with a mucilaginous coat, and thus protecting it from the action of the air and other irritants. An inflamed surface, whether within or without, is rendered worse by friction; therefore, in bronchial troubles, the inflamed surfaces are greatly irritated by the very act of coughing. Hence, persons are advised to "hold in," or try to refrain from coughing. All coughing beyond what is absolutely necessary for the removal of the accumulated mucus should be avoided, because it injures the parts affected by friction, and because it exhausts the patient; for the muscular exertion involved in a violent fit of coughing is very considerable indeed, and the muscular effort exerted by a patient with a bad cough during the twenty-four hours is really more than equivalent to that of many a man in a day's work. Both sedatives and mucilaginous substances can be employed, then, to check the excessive amount of coughing over and above that required to relieve the lungs and bronchial tubes of their accumulated mucus. To facilitate the removal of this, expectorants of various kinds are administered, according to the necessities of the case.

The difficulty in the way of recommending any one kind of cough remedy is that different coughs require different treatment, and what will relieve one may aggravate another. Then, too, the general health of the patient must be attended to, and the secretions kept open, etc. In short, the maxim, "What is one man's meat is another man's poison," applies here as elsewhere, and induces us to protest against the use of any nostrum simply because it cured a neighbor. —*Medical Weekly.*

ADULTERATION OF DRUGS IN ENGLAND.

The Society of Public Analysts report that the percentage of adulteration of drugs examined in 1880 was 16 per cent., against 28 per cent. in 1879. In most cases the pharmacists were not the delinquents. Many of the instances were of paregoric destitute of opium, sold by small shopkeepers who were not pharmacists, and therefore, prohibited by the British Pharmacy Act from dealing in an article containing poison. A curious distinction—the shopkeeper may sell paregoric without opium, while the pharmacist must sell paregoric with opium.

Sodium Bicarbonate.—Roster (Arch. d. Pharm., July, 1880) finds that this salt made by the Leblanc so-called American process, while it stood all the tests of the German Pharmacopœia, was found to contain nearly 4 per cent. of ammonium bicarbonate.

Assafœtida—Dr. J. Muter reports this drug adulterated by dropping properly formed pieces of magnesian limestone into melted assafœtida. It possessed outwardly an excellent appearance, but consisted of 79 per cent. of limestone.

Peanut Oil—Is largely used for adulterating chocolate.

Peru Balsam.—Fluckiger (*Pharm. Zeitung*, 1881) says that this balsam has, for many years, in Hamburg, been adulterated with rosin, benzoin, styrax, copaiba, and even castor oil, and mixtures of these substances. He bases his test upon —first, its specific gravity, which at 15 degrees Cent. must be between 1·140 and 1·145; second, ten drops of balsam produce, with four-tenths gramme of slaked lime, a mixture which remains soft and does not harden; and, third, when shaken with three times its weight of carbon bisulphide the balsam is separated into dark-brown resin, which clings to the glass, and should be about one-third its weight; and cinnamein, which imparts but little color to the carbon bisulphide.

Corks.—Old, and once used, are collected and bleached with sulphurous acid and recut.

Copaiba—Is reported to be adulterated with gurjun oil, but the writer thinks it improbable, for reasons of the high quoted price of the latter.

Quebracho.—Hitherto only the bark of the older and stronger trees has been imported, while that of the younger is better, containing a much higher percentage of active matter.

Potassium Bromide.—Maschke (*Pharm. Zeit.*) finds this contaminated with lead, which is detected by ammonium sulphide, but not by sulphuric acid.

Commercial bromide should contain not lest than 98 per cent. of pure bromide, the balance being chloride, sulphate or carbonate of potash, without any bromates or iodides.

COMMENT.

Your reporter does not find recorded in the medical press of this year as many instances of adulterated drugs as one would be led to believe have become prominent and notorious. It is asserted that the American market is one crowded by imports of drugs of low grades, or at least grades lower than those authorized in the official and standard works on materia medica.

The writer is not prepared to admit such assertions to be true, believing as he does that there is in this country a demand as well as abundant supply of crude foreign drugs of high grades, and that the intelligent purchaser can generally find his wants for such high grades easily and promptly met.

London, which is the drug receiving as well as drug distributing center of the world, has a well defined system of grading all drugs received from foreign ports, a system which probably has its analogue in this country in the grading of grain. So far as the writer can judge from his private experience and from published drug price lists, as well as those of importers and jobbers, no like system of grading obtains in this country.

The manufacturer and large buyer who is constantly in the market, if an expert, can control the relation between quality and price in his purchases, but to the moderate buyer, opium is simply opium, and whether it contains 5 per cent. or 15 per cent. of morphia, he is alike uninformed by its price or by any grade established before it is offered for sale. It seems to the writer important that every importation of drugs should be in some way graded, and its grade branded on each parcel in such a way that the least expert when buying shall know by official seal just what he is paying for. It seems to the writer as if it would be impossible to fix a legal standard for crude medicines, save one that shall be somewhat flexible and adjustable to the general average of good drugs, or one that shall establish certain grades based upon each drug having a fixed percentage of active matter. Many drugs are imported lower than the official standards, but which have a legitimate and proper value. For instance, opium for medicinal use, as opium and its galenical preparations, should have a fixed morphiometrical strength, but that is no reason why opium of higher or very much lower morphio percentage should not be used by the manufacturing chemist for the manufacture of morphine, provided he finds the relation of its cost to its morphio yielding value profitable to him.

Again, take the cinchonas. While it is imperative that the barks swallowed in substance and used in making the official tinctures should have a fixed and high quinia-alkaloid standard, it does not follow but that lower grades may be legitimately and profitably used by the manufacturers of the cinchona alkaloids, and it seems that there is a legitimate use for still lower grades of cinchona barks in replacing the simple tonics like gentian and colombo, for it must be conceded that the cinchona barks that contain, perhaps, nothing more than the cincho-tannates, must be better tonics than the simple bitters.

What, therefore, the writer thinks is greatly needed in this country in the primary markets and ports of entry for foreign drugs is a rigid official system of grading drugs, which shall insure to the buyer expert knowledge of what he pays for, and not the arbitrary exclusion of all drugs which shall not conform to high official standards.

In the execution of the newly-passed acts to prevent adulteration of food and medicine, it is not unlikely that with the appointment thereunder of an army of examiners, analysts, and other officials, spurred on by zeal to make their official acts show ample results, will overdo the matter oftentimes, as has been notably the result under similar recent legislation in Great Britain, and that many a poor grocer and still poorer pharmacist shall be made to feel the heavy arm of the law he has unwittingly and unintentionally violated. It must not be forgotten that in establishing these laws adapted to communities only of almost Utopian perfection, they have to apply in fact to a vast army of merchants in a country yet new and crude, whose preliminary drill and education in nowise compares to the standard implied and demanded from those these laws affect. One great reason why, heretofore, it has been so difficult to get favorable action from proposed pharmacy laws in the State legislatures has been a distrust among legislators of this kind of class legislation. It is also a common experience, that unless legislative enactments are in accordance with the needs of an overwhelming majority of the people, they simply encumber the statute books and are never enforced. Public opinions, like revolutions of nature, are of slow growth and of steady movement, but like the progress of a glacier adown its eroded valley, are as irresistible as fate, and it would seem the wise course to mould public opinion gradually to the groove it needs to follow in, rather than by any too radical haste defeat the purpose for which wise laws are framed.—*Oil and Drugs News.*

THE ACTION OF QUININE AND SALICYLIC ACID ON THE EAR.*

Kirchner has studied in the Pharmacological Institute of Wurzburg the action of these two drugs upon the ear with reference to settling the still open question whether their well-known specific action (tinnitus aurium) is due to congestion of the labyrinth. Clinical observation has long since proven that they directly produce subjective noises, usually described as ringing, and also a certain, and often a very marked degree of deafness. Both of these symptoms usually pass away when the administration of the drugs is stopped; but occasionally, when the drugs have been given in very large doses or for a long time, both symptoms continue and become a lifelong and serious affliction. Notwithstanding the fact that these clinical symptoms have been seen so often, but few anatomical observations on their causes have been made.

For his experiments Kirchner used rabbits, cats, dogs, guinea pigs, and mice; for his clinical observations he had a garrison hospital situated in a malarial district. His conclusions are that quinine and salicylic acid produce hyperæmia of the tympanum, which may go on even to hemorrhage, and that the whole labyrinth is likewise involved in this hyperæmia, which is often so intense that, if it continued any length of time, it must necessarily injure the ultimate nerve fibers. The cause of this hyperæmia is referred to vaso-motor disturbances, which may produce in severe cases a paralysis of the vessels and an exudation in the various parts of the ear—the same conclusion which had been reached previously by Weber-Liel, Roosa, and others.

THE ACTION OF QUININE AND SALICYLIC ACID ON THE HUMAN EAR.†

In conjunction with Dr. Guder experiments were instituted upon twelve young and healthy medical men with the following results, one gramme of quinia muriatica being given:

1. A gradual fall in the temperature of the external meatus in the course of two and a half hours, averaging 56° C. and corresponding with the fall in temperature of the whole body.

2. No hyperæmia of the meatus or drum-membrane and no injection along the manubrium was noticed within that time or later. On the contrary, in five of the cases the slight injection which previously existed disappeared.

3. Subjective noises, as roaring, buzzing, or ringing, were always produced in from one to one and a half hours, and disappeared gradually within twelve hours.

4. After from two to three hours a decided diminution of the hearing showed itself, to disappear gradually as the subjective noises ceased.

5. In eight of the cases dizziness, usually slight, but in some severe enough to cause a staggering gait, came on with the subjective noises.

The greatest loss of hearing appeared at the time when the temperature was the lowest.

* Kirchner, in "Berliner Klinische Wochenschrift," No. 40, 1881.

† Weber-Liel, in "Monatschrift fur Ohrenheilkunde," No. 1, 1882.

Similar experiments were used in conjunction with Dr. Sachs to determine the effect of salicylic acid, the conclusions being, as follows, from taking four and a half to five grammes of the salicylate of soda in two doses at an interval of fifteen minutes:

1. A diminution in temperature of the meatus averaging 0·35° C. within two or three hours.

2. No hyperæmia of meatus or injection along the manubrium, and where any such already existed no change whatever was noticed.

3. Roaring, singing, and occasionally ringing were felt in all cases in from two and a half to four hours, and lasted longer than similar noises produced by quinine.

4. The loss of hearing was very marked, and continued in several cases for some days; in several cases where the ears were diseased the loss of hearing continued much longer, in one case, it is said, for six months.

5. Decided dizziness was noticed in seven of the twelve cases, beginning somewhat later than the subjective noises.

Comparing the second series (salicylic acid) with the first series (quinine), it was found that in the second the fall in temperature was less, but the diminution in the hearing was greater and continued longer.—*Amer. Jour. of Otology.*

EAR DISEASE.

JAMES L. MINOR (*Virginia Med. Monthly*, November, 1881) has collected fifty cases of ear disease at St. Joseph's Industrial Home, and of these forty-two were girls and eight boys. Of the diseases, forty-two were chronic suppurative inflammation of the middle ear; four, impacted cerumen with chronic aural catarrh; three were chronic aural catarrh, and one eczema of the auricle. Of the forty-two cases of otorrhœa, both ears were affected in thirty-two, making a total of seventy-four tympana in a state of chronic suppurative inflammation. The drum heads were perforated in all instances. Twenty-nine cases were cured with restoration of hearing and an entire reproduction of the drum-heads; eleven were cured of the inflammation, and the remaining cases were in various stages of improvement.

Boracic acid was the most successful agent he found in the treatment; a warm, saturated solution of boracic acid was first used to thoroughly cleanse the ears; they were then dried with absorbent cotton, and the meatus about one quarter filled with finely-powdered boracic acid, dropped through a quill. The powder and syringing were repeated whenever the discharge was abundant. For the nasal catarrh, the nose was cleansed first with a spray of the acid and then the powdered acid was either blown or snuffed into the nostrils.

Boracic acid is not an irritant to inflamed surfaces, and its action on inflamed mucous membranes and granulations may be divided into two stages: "The first gives rise to a sensation of slight warmth and moderate stimulation, and is associated with an abundant serous discharge from the succulent tissues. This gradually merges into the second stage, which is one of ease and relief, and is accompanied by a marked reduction in volume of the inflamed tissues. The diminution in size is evidently due to the depurative action of the acid on the swollen tissues during the first stage, and is especially noticeable in succulent polypoid growths with a purulent discharge (granulation). I have frequently noticed the granulations to shrink and disappear entirely under its influence, where removal by the snare and cauterization with nitrate of silver or nitric acid seemed to stimulate them to increased growth. The first stage lasts from one to six hours, and the second from six to forty-eight."

SIMPLE DIRECTIONS FOR COLLECTING, PRESERVING, AND PACKING INSECTS.

By FREDERICK LEROY SARGENT.

IT is the object of this article to offer to those who are interested in studying the common insects around them, directions sufficiently plain and practical to enable such persons to collect and preserve any specimen they may come across. It is also intended to help those who have developed a desire to make a serviceable, systematic collection.

APPARATUS FOR COLLECTING.

More or less apparatus will be needed by any one proposing to make a collection; nevertheless, occasional captures may be made without special apparatus, as will be shown hereafter.

A good collecting outfit need only consist of a net, a collecting bottle, some paper pockets, and some pill-boxes.

The net, Figs. 1 and 2, may be made after the following plan:

The handle should be at once strong and light, heavier at one end than at the other, and about 4½ feet long. A stick, such as used by farmers for their whips, or the right length from a bamboo fishing pole, is excellent. The best thing to use for the ring is a piece of rattan, 3 feet or more in length. If this cannot be obtained there may be substituted for it the same length of a good barrel hoop, shaved down to one-third of an inch in width. A piece of rather stout brass wire about a foot long is put through a hole bored at the smaller end of the handle, 3½ inches from the tip, and then it is bent as shown in Fig. 2, and bound firmly to the stick with small copper wire.

The ends of the rattan or hoop are similarly bound to the diverging ends of the brass wire, thus making the framework of the net.

The ring is covered with a strip of cotton cloth 2½ inches wide, and to this is sewed a bag of mosquito netting about 2½ feet deep and of the shape figured. It is well to have the bag of some dark color, such as green or blue.

The net above described possesses many advantages over the nets ordinarily used.

The collecting bottle consists of a wide mouthed jar or bottle having something in it whereby the air is kept charged with poisonous vapor. The best substances to use for this purpose are potassic cyanide and chloroform. Bruised laurel leaves are also recommended. Many different ways of fixing up the bottle answer the purpose. As for instance, a cavity may be made in the cork and filled with a wad of cotton, and this kept saturated with chloroform while the bottle is in use; or the bruised leaves of the little red sheep laurel (*Kalmia angustifolia*) may be substituted for the cotton and chloroform, if only small insects are to be collected. The most convenient collecting bottle, however, is one having a few pieces of potassic cyanide in the bottom, covered with a layer of plaster of Paris The plaster is mixed with water to the consistency of thick cream, and then quickly poured over the cyanide in the bottle. When hard it forms an even floor on which the insects may rest without coming in contact with the cyanide, but still being subject to the influence of its fumes

T make the cork perfectly air-tight it may be soaked in melted paraffine.

The paper pockets consist of square pieces of newspaper, folded on the diagonal and the edges turned over. They are very useful to keep butterflies in until they are to be prepared for the cabinet.

Pill boxes suitable for small specimens, such as cocoons, eggs, beetles, etc., may be purchased cheaply at any wholesale drug store.

METHODS OF CAPTURE AND HANDLING.

Collecting may, as before stated, be either with or without special apparatus. We will first consider the methods used in the former case.

The net is used either to "scoop" an insect while flying, or it is thrown over an insect at rest. Collecting the minute insects which swarm in fields is accomplished by sweeping the net vigorously through the grass.

In "scooping," after the insect is in the net a twist is given to the handle, and thus the bag is closed and the creature imprisoned. All this is done in one movement, consisting of a *swoop* ending in a *twist*.

The insect once in the net, the next care is to remove it uninjured. If a large moth or butterfly it should be confined within a small space at the end of the net. It may now be grasped from the outside of the net, at that part of the body where the wings arise (the thorax), and held firmly while the other hand is inserted in the net to take hold of the insect at the same place. It may be taken out now and put into the collecting bottle or a paper pocket. In the case of a small butterfly or moth or a stinging insect handling is out of the question; so, to avoid contact, the mouth of the collecting bottle is placed over the insect from within, the bottle closed and removed from the net.

When collecting without apparatus, as will frequently be necessary even to a regular collector in emergencies, the methods are more crude and often require much dexterity. A few general principles only can be laid down, together with one or two practical tricks. First, in handling any of the *Lepidoptera* (butterflies and moths), under no circumstances should the wings be taken hold of; the insect should be grasped by the thorax. In all insects especial care should be exercised to prevent injury to the *antennæ* or feelers; as much of the value of a specimen depends on them. Care should also be taken to keep the legs of beetles, bees, etc., intact.

It must not be supposed that when a fine butterfly is seen it is useless to attempt its capture if a net is not at hand. It may oftentimes be stunned by a dextrous blow with the back of the hat and thus brought to the ground.

A delicate insect, or any one which it is not desirable to handle, that may be on a wall or window-pane, or in a situation similar, may be taken uninjured by placing a bottle, tumbler, or the like over the animal, and then sliding a stiff piece of paper between the surface and the vessel, and by thus closing the latter, imprison the insect.

The best way to kill a large moth or other insect with great tenacity of life is to expose it to the fumes of a mixture of potassic cyanide and chloroform under an inverted jar or tumbler. Beetles are almost instantly killed on being plunged into hot water. Many bees, hornets, flies, and, in fact, most insects devoid of delicate hairs or scales, may be similarly killed without injury to their appearance.

On the principle that "necessity is the mother of invention," various expedients will doubtless suggest themselves to the collector under various circumstances. The above are merely mentioned as some which have been found useful in the experience of the writer.

WHERE TO LOOK FOR INSECTS.

In regard to such a subject as this, experience will teach vastly more than any directions ever could. A few hints only can be thrown out.

When hunting butterflies, bees, and other day flying insects, particular attention should be paid to swampy places, rich in the larger and more gaudy flowers. The milk weeds, Joe-Pye-weed, thistles, clover, and honeysuckle, and, in fact, all the fragrant honey-bearing flowers, are frequented by diurnal insects. Shortly after sundown the sphinxes and other crepuscular moths may be taken hovering over tubular flowers, such as the evening primrose, and especially are they attracted by petunia beds.

Night-flying moths keep mostly in the woods. In the cities many handsome specimens of moths and beetles have been taken near street lamps, toward which they have been attracted by the light. Dragon flies and the like are found abundant in the vicinity of ponds and brooks. Different species are found at different places, even though they be quite near each other.

Beetles are to be sought for along the sandy road, in the orchard, woods, pasture or field, on flowers, fruit, and carrion, under stones or sticks, and under the bark of trees. These creatures are continually presenting themselves at the most unexpected times and places, and the collector will do well to be always prepared to take them.

PREPARING FOR THE CABINET.

It is the custom among insect collectors to impale nearly every specimen with a pin, so that the insects may be arranged in the cabinet or studied without injuring them. The different kinds of insects are not all pinned alike, and therefore it will be necessary to discuss the various ways separately. Some insects which it is not desirable to pin are fixed in a manner to be spoken of hereafter.

All the *Hymenoptera* (bees, wasps, etc.), *Lepidoptera* (butterflies and moths), *Diptera* (two-winged flies), *Neuroptera* (dragon flies, etc.), are pinned through the middle part of the thorax, that is to say, between the points of insertion of the wings. (See *x*, Fig. 3.)

The *Orthoptera* (locusts, katydids, etc.), are impaled through the shield, which is at about the same place.

Hemiptera (bugs, harvest flies, etc.), are, as a rule, pinned through the *scutellum*, which is a conspicuous triangular piece about the middle of the back. (See *x*, Fig. 5.)

The *Coleoptera* (beetles) are pinned through the *right* wing cover, so that the pin passes through the body and comes out between the second and third pairs of legs. (See *x*, Fig. 4.) The insects should all be about two-thirds up on the pin. This is important, because any unevenness in height among them looks bad in the cabinet. Care should be taken to avoid having to put the pin into the insect more than once, as a very unpleasant greasiness is often the result when several holes are made.

It is customary to use pins which are made expressly for pinning insects, and these, known as "entomological pins," are sold by dealers in naturalists' supplies for 15 cents per 100 or $1.25 per 1,000. As the finer and even the medium-sized pins are very apt to bend, and so become rather troublesome, it will be found on the whole most advisable to use pins as large as the size of the insect will permit.

The object of a collection of insects being not only to show a number of different species, but also to show the characteristic parts of each specimen to the best advantage so that they may be satisfactorily examined and compared, it becomes necessary to know how to accomplish this end.

The principal apparatus needed are some wooden forms to use in spreading the parts until they dry in position; a box of black glass-headed pins (sold under the name of mourning pins), and some very fine cambric needles. The latter are for drawing the wings and other parts into position, while the former are used for keeping them in the position they are thus made to assume. The needles are much more easily used if inserted in wooden handles 3 or 4 inches long.

Two kinds of spreading forms will be found useful. The first of these (shown in Figs. 6 and 7) consists, it will be seen, of two wedge-shaped pieces of wood, separated from a plane piece forming the bottom by four small wooden blocks, the whole being fastened together by screws passing through the three thicknesses of wood from beneath.

If slots be made in the lower piece of wood for the screws to slide in, the distance between the upper pieces may be regulated to the size of the body of the insect to be spread. This kind of form is used for spreading those insects which have large or medium-sized wings, such, for example, as most of the *Lepidoptera*, *Neuroptera*, and *Orthoptera*. The insect having been pinned, it is stuck in the form so that the body comes between the two top pieces of wood. The wings are now drawn into position with the needles, and then fastened there either by putting the pins through the wings near the stronger parts, or else by pinning strips of card on to the wood so as to press upon the wings. The other kind of form (shown in Fig. 8) consists simply of a rather thick piece of wood, having bored in it a series of holes about the size of the head of one of the pins, and of a depth equal to one-third the length of the pin. The bottom of each hole should come down to a point, so that when a pin is put in head first it will be held firmly. Forms of this kind are used for spreading insects having wings too small to be conveniently managed on the other kind, or else those needing especial attention in the arrangement of legs, etc.—such in

COLLECTING AND PRESERVING INSECTS.

sects as the smaller *Lepidoptera, Hymenoptera, Diptera, Hemiptera*, and *Coleoptera*.

After pinning, the insects are put on the forms with the underside uppermost, and the different appendages held in position by the same means as before.

The insects should remain on the forms until thoroughly dry and stiff; that is to say, from one to three weeks or over, according to the size of the insect and the humidity of the atmosphere.

The wood used in the construction of both kinds of forms should be the softest white pine. A coat of shellac improves them. All that are used should be so made that every one of the insects will stand at the same height on the pin.

The object of spreading insects, as before stated, is to display their various parts to the best advantage. The following hints may be of service, as they express the usual ways in which this is accomplished.

The wings of *Lepidoptera* should be so spread that the lower edges of the forewings shall be on a line with each other; and the hind wings brought slightly forward to conform to them. The *antennæ* (feelers) should be in the same plane as the wings, and nearly parallel to the front edge.

Orthoptera require much the same treatment, especial care being taken, however, to display the legs to advantage. The wings may be either expanded or closed.

Hymenoptera, Diptera, and *Neuroptera* have the wings brought slightly forward and the legs carefully arranged.

The chief point that requires attention in the setting up of *Coleoptera* and *Hemiptera* is the proper arrangement of the legs and *antennæ*, especially the latter.

There are some insects, such as the flea-beetles, weevils, and the like, which, from their small size, cannot be pinned without distorting them and increasing the difficulties of examination. They may be glued on to little pieces of card, or, preferably, mica, and the pins inserted through the latter.

The following is a good way to protect delicate *antennæ* or fragile legs from sudden jars or knocks, and consequent breaking off. Below the insect, on the same pin, put a piece of stout card-board, larger than the insect when fully spread; press it close up, and then arrange the different parts on it, fastening them in position with glue or gum. A disk of cork pressed on to the pin and glued to the under surface of the card-board will keep it permanently in position.

Painting insects with mercuric bichloride (corrosive sublimate) dissolved in alcohol, has a tendency to prevent the attacks of cabinet pests. This process cannot be applied, however, to any insects covered with hairs or scales.

When it is desired to render a dried insect pliable, so that it may be reset, this may be done by keeping it in a moist atmosphere. To do this various means are resorted to. One way is to place the insects on some moist sand in a box, and, covering the whole with a damp cloth, let them stay there for about twenty-four hours. The best way to do when the relaxing process is to be much resorted to is to take a stone jar, put some potassic cyanide and water in the bottom, and lay the insects on a tray suspended over the mixture. The cover may be put on and the insects allowed to remain for several days if need be, without danger of their moulding.

DISPLAYING IN CASES.

Collections on which any value is placed are kept in cases or in the drawers of a cabinet. The former is the more general way.

The essential qualities of good insect cases are that they exclude dust, shield the specimens from the fading action of light, and, above all, that they exclude the little insect pests which so quickly destroy collections.

Quite good cases made of *papier mâché* are sold cheaply by dealers in naturalists' supplies. Wooden ones are also sold. It will probably be found more satisfactory, and, on the whole, cheaper, to purchase cases from some dealer for whom large quantities are manufactured than to make them for one's self.

As a help in keeping out insect pests, one or two small bottles filled with potassic cyanide, and having in the mouth a plug of loose cotton, should be fastened inside of each case. This, however, must not be wholly relied on; the boxes should be made as nearly air-tight as possible, and then, unless the most expensive kinds of cases be used, it will be necessary to make an examination of the collection every little while that any intruder may be killed. Otherwise valuable specimens may be lost. Should any living insects be found in the cases, the best thing to do is to pour a little chloroform on the bottom of the case and then tightly shut it. In a short time this will bring many out of their hiding places, and many it will have killed.

A collection, to be of much service, should be catalogued. A very good way is to attach to each specimen on the same pin a different number. In a blank book there are corresponding numbers arranged consecutively; and, following the number of a specimen, should be written its Latin and its English name and synonyms, if any; its classification, the locality and date of collection, any references to notes made on the circumstances of collection, habits or development of the insect, agricultural importance, or any other points of interest in regard to it. When the name of the insect is unknown, the number attached to it answers the purpose almost as well.

PACKING FOR TRANSPORTATION.

Many persons are often obliged to do the greater part of their collecting away from the place where they keep their collection. This is largely the case with those who live in cities, and who do their collecting in the country. It therefore becomes an important question how to pack insects for transportation, so that they will go without injury.

The safest way is to put in paper pockets all the larger winged ones. All that cannot be so packed may be wrapped in pieces of tissue paper, twisting the ends instead of folding them over. They may now be packed in a comparatively small space, and at any future time relaxed and spread as before directed. It is well to attach a separate number to each specimen as it is put away, and make entries in the catalogue before the dates, etc., are forgotten.

Another way is to pin the insects and pack them in boxes, as closely together as possible, leaving the spreading to be done after they are unpacked. Although this method has its advantages, the great danger is that some of the specimens may get loose, and, rattling round among the others, make havoc in *antennæ*, legs, and wings. Especial care should, therefore, be taken when this method is adopted, to put the pins into the wood very firmly. Unless the pins are quite stout, and the wood of the box very soft, the latter will have to have a number of slices of cork fastened inside the box to put the pins in, or else the box will have to be lined with sheet cork or some substitute.

POSSIBLE FOOD PLANTS FOR THE COTTON-WORM.

ONE of the most interesting characteristics of the cotton-worm is that it is so strictly confined to cotton as its food plant. All attempts hitherto made to discover additional food plants have proved futile; nor have we been able to ever make it feed successfully on other plants allied to Gossypium.* We have, however, long felt that there must be some other wild plant or plants upon which the species can exist, and this belief has been all the stronger since it was demonstrated two years ago from observations made by Dr. P. R. Hoy, that the larva may occur in Wisconsin, and consequently out of the range of the cotton belt.† We have given special directions to those in any way connected with the cotton-worm investigation to search for additional food plants, but so far no additional food plants have been discovered.

Last November we received from Dr. J. C. Neal, of Archer, Fla., specimens of a plant with eggs and newly hatched larvæ, which he believed to be those of Aletia, but which belong to an allied species—the *Anomis erosa*, Guen. The plant proved to be one of the Malvaceæ (*Urena lobata*, Linn.), which is reported as quite common in that part of Florida and further south, being a tall branching and straggling weed with annual stems and perennial root, from which new shoots arise in January. It blooms from February to December, and is, in addition, a valuable fiber plant, the bark of both stem and root being very strong, and used very generally for whip and cording purposes. The leaves have three very conspicuous saccharine glands on the principal veins toward the leaf stem, and the plant, Dr. Neal reports, is much less sensitive to cold or frost than Gossypium. We find that the plant has been received by Dr. Vasey, botanist of the Department of Agriculture, from several parties in Florida, with inquiries as to the value of the fiber.

Urena lobata was, until very recently, not known to occur in the United States. It is common on dry hill pastures almost everywhere in the West Indies and southward to Guiana and Brazil, and is also reported from Western Africa, East Indies, China, and some of the Pacific islands. It seems to thrive very well in Florida, and is likely to spread to other adjacent States.

The *Anomis erosa*, the eggs and young larvæ of which were not uncommon on the leaves of the Urena, may be distinguished from Aletia by the paler, more translucent character of both egg and larva, and by the first pair of prolegs being quite obsolete, in which character it resembles the *Anomis exacta* that affects cotton in Texas. Aletia larvæ that had been fed on cotton, when placed upon the Urena refused to feed upon it, and finally perished.

We recently took occasion to carefully examine the Malvaceous plants in the herbarium of the Department of Agriculture with some quite interesting results, although a herbarium is naturally the least favorable place one can choose for an entomological investigation of this character, as plants that are least injured by insects are most apt to be collected, and the mode of preserving the plants still further reduces the chances of finding traces of Aletia, because only one side of the leaf is available for examination. How small this chance is, may be illustrated by the fact that on the specimens of Gossypium in the herbarium, no Aletia eggs or egg shells could be discovered, and that only one specimen showed any trace of being injured by any insect whatever. Nevertheless a number of eggs or fragments of such—some of them from their structure very closely related to Aletia, were found on the following plants: *Malvastrum spicatum*, from Florida and Nicaragua; *Urena ribesia* (which is considered a form of *U. lobata*), from South Florida; *Pavonia typhaleoides*, from Cuba; *Sida glomerata*, from Cuba.

One object of this examination was to discover, if possible, the particular Malvaceous plant upon which Aletia feeds in the States north of the cotton belt, but this proved to be an almost complete failure, because the herbarium contained only six specimens of such plants from the more northern States, not counting sixteen specimens cultivated in the agricultural grounds at Washington. However, on a specimen of *Sida spinosa*, from York county, Penna., an egg was found which has every appearance of that of Aletia.

We would earnestly call upon entomologists who may read these pages to aid us in obtaining evidence of the food plant of the insect in the more northern States by an examination of the plants indicated by an asterisk in the following list, as it is upon such that the insect will probably be found at some future time, but only late in the season:

LOCALITIES FOR MALVACEOUS PLANTS FROM GRAY'S FLORA.

Althæa officinalis, L.—Salt marshes, coast of New England and New York. (Nat. from Eu.)

Malva rotundifolia, L.—Waysides and cultivated grounds, common. (Nat. from Eu.)

Malva sylvestris, L.—Waysides. (Adv. from Eu.)

Malva moschata, L.—Has escaped from gardens to wayside. (Adv. from Eu.)

Malva alcea, L.—Has escaped from gardens in Chester County, Penn. (Adv. from Eu.)

Callirrhoë triangulata, Gray.—Dry prairies, Wisconsin, Illinois and southward.

Callirrhoë alcæoides, Gray.—Barren oak lands, Southern Kentucky, and Tenn.

Napæa dioica, L.—Limestone valleys, Pennsylvania and southward to the valley of Virginia, west to Ohio and Illinois, rare.

* *Malvastrum angustum*, Gray.—Rock island in the Mississippi, Ills.

* *Malvastrum coccineum*, Gray.—Abounds on the plains from Iowa and Minnesota westward.

* *Sida napæa*, Cav.—Rocky river banks, Penna., York County, Kanawha County, Va. (Cultivated in old gardens.)

Sida elliottii, T. & G.—Sandy soil, Southern Virginia and southward.

* *Sida spinosa*, L.—Waste places, common southward.

Abutilon avicennæ, Gærtn.—Waste places, escaped from gardens. (Adv. from India.)

Modiola multifida, Mœnch.—Low grounds, Virginia and southward.

Kosteletzkya virginica, Presl.—Marshes on the coast, New York to Virginia and southward.

Hibiscus moscheutos, L.—Brackish marshes along the coast, sometimes extending up rivers far beyond the influence of salt water (as above Harrisburg, Penna.), also Onondaga lake, New York, and westward, usually within the influence of salt springs.

Hibiscus grandiflorus, Michx.—Illinois and southward.

Hibiscus militaris, Cav.—River banks, Pa., to Ill., and southward.

Hibiscus trionum, L.—Escaped from gardens or grounds. (Adv. from Eu.)

Hibiscus syriacus, L.—Escaped from gardens or grounds. (Adv. from Eu.)

Of these twenty-two species, eight of which are introduced, at least eleven are not likely to occur in Wisconsin, so that the number of plants upon which the insect will probably be found is very limited, if, as is most probable, the plant really is one of the Malvaceæ.—*C. V. Riley, in American Naturalist.*

* The only partial success in this line is that mentioned in our Bulletin on the Cotton-worm, p. 12.

† See Report on Cotton Insects, Department of Agriculture, 1879, p. 89.

EXPERIMENTS WITH CAGED PYTHONS.

LIEUTENANT T. HUTTON, 37th N. I., transmitted to the Asiatic Society of Bengal some curious observations on the *Python tigris*, or Indian boa constrictor, made on several of these reptiles which he kept alive. He states that the notion that, after crushing their prey, they lubricate it with their saliva to facilitate deglutition, is erroneous. After winding their death-knot round the victim, they constantly dart out their tongue, apparently to feel for the head. He thinks the tongue of serpents is, in a great measure, their organ of touch or feeling. When he offered water to these animals they felt the pan all over with their tongue till it touched the water, and then, dipping their nose fairly into it, drank it by long draughts. They endeavor to seize their prey by the head, but if it move away they seize where they can; but having crushed it, invariably commence swallowing the head. Sometimes they experience great difficulty in getting their prey down. A boa, eight and a half feet long, having commenced swallowing a partridge, seized it rather on one side, and one of the wings would not enter his mouth, whereupon he threw a coil tight round his own neck, and then drawing his head and prey backward through it, the wings were smoothed down and lengthened so as to be easily swallowed.

In May a large one cast his skin. This he did by first rubbing his muzzle against the side of his cage until the skin became detached from the lips, and then gliding slowly through and through the tight-drawn folds of his own body, by which means the skin was thrust further back until it was all off, and he had fairly "crept out of it."

This reptile coils round and crushes his victim with the speed of thought: "The eye cannot follow the rapid movements of the folds. Gliding very gradually—almost imperceptibly—toward its fascinated and trembling prey, he throws himself upon it, seizing it by the head or leg in his powerful jaws, and simultaneously winding coil on coil round the neck or body. It is in the first movement that the tremendous muscular power of his body is brought into play; and the folds formed at the very instant of seizure are compressed with such desperate energy as to render the victim utterly helpless in his grasp, and the most convulsive efforts are useless, merely shaking the dreadful monster without in the least loosening his folds; nay, on the contrary, only rendering them still tighter, till life has fled. I have tried," adds Mr. Hutton, "with my utmost strength, to uncoil a boa of seven feet from a partridge, but with not a shadow of success, for he tightened his hold the more for my endeavors."

The velocity with which the boa darts on his prey not only overturns it but hurls his own body in advance of his head, and thus forms the first coil, the rest of his length being rapidly turned at the same time. Lieutenant Hutton introduced a fullgrown buck-rabbit into a den: "The rabbit eyed its monstrous inhabitant with evident uneasiness, his ears thrown back, nose elevated, and hind feet stamping firmly on the floor. In the meantime his enemy was incessantly brandishing his long-forked tongue, and gradually opening out the close-drawn coils of his body in order to give himself room for the deadly spring. His head then slowly glided forward over the upper coil toward the rabbit, which intently eyed every movement of his foe. In an instant, and with a suddenness that made me start, the snake dashed forward, but, to my surprise, the rabbit eluded his grasp by springing over him. With a loud and threatening hiss the boa suddenly gathered himself again into his corner, where he lay still for an instant with his head still pointed toward the rabbit. Not liking his position, the poor buck turned to move away, and that movement decided his fate; for with lightning speed both snake and rabbit were rolled in a fast embrace, tumbling with heavy crash against the side of the cage. The boa had seized a foreleg with one coil drawn so closely round the throat that the eyes seemed starting from their sockets; a second coil was thrown round the body immediately below the shoulders; a third round the loins. So instantaneous was the spring that not even one cry escaped the rabbit, and though the last convulsive motion of the hind legs was strong enough to shake the boa it lasted but a few minutes and all was over. But for some seconds after life had fled, the snake still held his firm position as if to allow no chance of escape, and then proceeded first to disengage his teeth from the hold he had taken; secondly, to uncoil from the neck; with the remaining coil he still held fast."

The process of deglutition is described as frightful: "the snake, with mouth wide open, seems to draw himself over the prey, as a stocking slips over the leg."

A goh (species of monitor lizard) was destroyed in the same manner as the rabbit; but a different result took place on the introduction of a large cat. "I had always been in the habit," says Lieutenant Hutton, "of introducing the prey into the cage by a side door, and from a corner of the den the spring was made almost before the animal introduced was aware of the danger in which it stood. Had the cat been thrust in in like manner, she would have had no time to prepare for combat; nothing, however, would satisfy my visitors on this occasion but turning the snake out of his den into an open veranda, in which the cat was already tied by one leg. The boa, frightened by the noise and number of people collected, endeavored to make his escape, and for this purpose was passing on without noticing the cat, when to my surprise, she seized the boa by the thick part of the tail with her teeth, shaking him forcibly from side to side, while her claws were making sad havoc on his sides. The boa made no attempt to bite, but as soon as the cat quitted her hold took refuge in the cage and coiled himself up as usual. Victory, of course, was awarded to the cat, as though there had been a fight between them. A second trial brought the same result, and I then shut the snake up, as he appeared hurt from the sharpness of the cat's teeth and claws. The cat was then introduced into the cage, and the boa, disturbed and discomfited as he was, instantly sprang at and seized her by the leg; but the cage proving too confined for contest with so large an animal as the cat, he could not coil round her, and puss, getting her

leg at liberty, again brought her claws to play upon the sides of her antagonist, who finally gave up the struggle, and despondently coiled himself again in a far corner."—G., in *Land and Water*.

MALAGA RAISINS.

IN a recent report by British Consul Marston, of Malaga, there are some interesting details relating to the production and preparation of Malaga raisins. He states that in Andalusia there are two distinct vines, the Muscat and the Pero-Ximenez, the first indigenous, the second imported from the borders of the Rhine 200 or 250 years ago, by a German, whose name, corrupted in Andalusia, was given to the vine. Opinions differ as to the respective merits of these two vines. The cultivation of the vine is as follows: The soil is dug out round the root, leaving a circular hole about one foot deep; and owing to the firmness of the soil, the operation is somewhat difficult. Manure of great strength is plentifully used by many proprietors. Different from Southern Italy, the vines here stretch themselves over the ground, and gather all atmospheric heat. Although white, the grape has a golden tint, and the skin is resisting and slightly tough. The branches appear like roots. The vintage is conducted with great care; all the fruit is not gathered at one time, but the same piece of ground is gone over three times, in order that the grapes may have the necessary ripeness. There are different methods of preparing the raisins—washing, drying by steam, and the simple drying in the sun. The drying by steam is more particularly followed in the province of Denia, because of the sufficiency of solar heat. It is also employed in the south, in case the season is wet during the vintage. The cut grapes are put in baskets, and carried either on the backs of mules or donkeys, or in carts, to the places, often distant, where they are prepared, and although they transport the fruit with great care, it naturally suffers. The skin often breaks, which renders the drying difficult, if not impossible. To dry the grapes by the washing method, furnaces are constructed, of feeble draught, in which wood is used as fuel; a round kettle, varying in capacity from 300 to 400 liters, receives a lye formed from the residue or refuse of the grape after pressing. The lye used is either that obtained from the present year or that which has been kept from the previous vintage. Placed in wire colanders, with long handles, containing from two to three kilogrammes each, the raisins are plunged in this lye, boiling at a temperature of about 212° Fahr. After this first immersion, the workmen examine the skins to see if they are sufficiently shriveled; if not, they immerse the grapes a second time, usually the last. This process of immersion is a very delicate one, and requires skillful watching and great judgment on the part of the workman who conducts it. According to the quality of the skin, the immersion should be more or less rapid, to save the grapes from bursting; much skill is also necessary to recognize the fissures which may appear. In cases where the heat has been too great, the raisins too rich in sugar will mould shortly after being packed. This process offers, among others, the inconvenience of exposing the raisins to fermentation during transportation, it necessitates expense for the construction of furnaces, besides the indispensable last drying in the sun; no matter what grapes employed, or what care bestowed upon the preparation, the results will always be relatively inferior. The method of preparing raisins by steam is as follows: After having been exposed nearly twenty-four hours to the sun's rays, the grapes are carried on boards under cover to a building arranged with shelves, six or seven feet high. Heat is produced by steam that circulates, in an iron tube seven or eight inches in diameter, through the entire building. It is unnecessary to submit the grapes to a jet of steam, which would injure them by making them damp, but to a veritable heat of 160° Fahr.; valves arranged on the floor cause an even temperature. At the end of twenty-four hours the drying is usually finished; but as the immediate transfer from a temperature of 160° Fahr. to the open air would injure the ultimate result, it is necessary to let raisins cool gradually in a room constructed for the purpose, adjoining the heated room; and only when the raisins are entirely cool are they carried to the stores for packing. The following is the process generally employed in Malaga, a process the people are endeavoring to extend to other less favored climates: The sun furnishes all the heat required; it is sufficient to construct divisions of either brick or stone exposed to its rays in an inclined position, say ten yards long and two yards wide; the divisions or apartments are built up at one end with a sort of triangular masonry, which, from a distance, gives them the appearance of a range of uniform tombs. The triangle is so constructed, that the sun never fails to shine upon the contents, the interior being covered with fine gravel which attracts the heat. Immediately after gathering, the grapes are placed in these divisions, and are exposed to the heat of the burning Andalusian sun. Experienced cultivators affirm that during the heat in August, they attain a temperature of 145° Fahrenheit. At nightfall a very simple method of covering is applied to guard the fruit from the heavy dews or rain, either composed of sailcloth or heavy canvas, so arranged that it covers entirely the grapes that are drying within, and being supplied with rings on two sides, slides up and down like a curtain. In many places boards or planks are used, giving the appearance of a roof. During the process of drying, those grapes which remain green or are spoiled are carefully removed, and each grape is turned, in order to preserve a uniformity in the darkening of color. Competent judges give the preference to this simple method of drying, as much for the results as for the simplicity of the process. The raisins that have been prepared by the scalding process dry in four days, while those dried by the sun take ten days, but this loss of time is largely compensated by the economy of expenditure. The raisins are not ready for packing immediately after being dried, but have to be kept several days in the stores on the planks on which they are carried. The raisins that are spoiled or defective are picked out, especially any that may be broken or bruised, out of which one drop of moisture would probably damage a whole box, and very great care has to be exercised in this picking out. Finally they are classified, which is an operation exceedingly difficult, as cultivators and merchants differ greatly in their opinions; the merchants nearly always remodel the boxes packed by the producers. The boxes are mostly made by contract, at a cost of about sevenpence halfpenny each, the best being made of fir imported from Portugal. The producer almost always provides the boxes and packs them, but they are always repacked in the towns by the merchants, who usually employ women or girls for this work. All raisins are packed in boxes, except those shipped in barrels and frails, and are divided into four layers in each whole box, which, if of full size, contains 22 lb. of fruit, the total weight, with the box, usually being 28 or 29 lb. The crop of raisins produced in the Malaga district from the vintage of 1880 and 1881, is estimated at between 2,000,000 and 2,050,000 boxes. The stock of raisins at present in the province of Malaga is estimated at about 150,000 boxes, while one year ago it was estimated at only about 50,000 boxes.

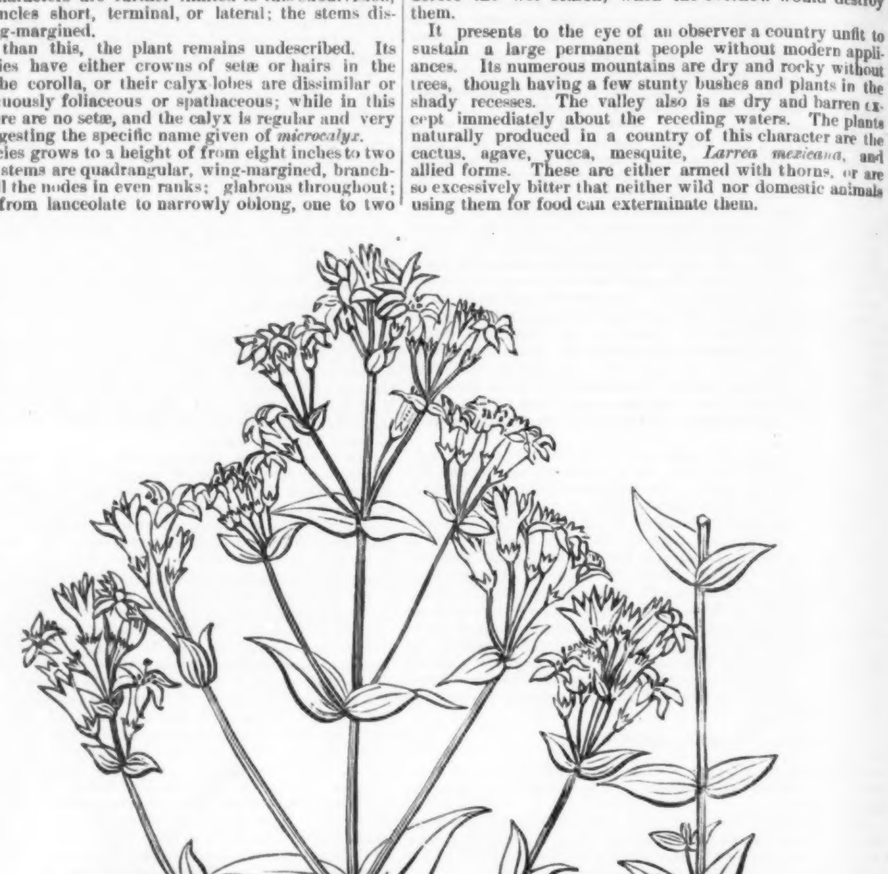
A NEW GENTIAN.*

Gentiana microcalyx, Lemmon (summit of the Chiricahua mountains, in southeastern Arizona, Sept. 30, 1881).—Comparing this plant with descriptions in Dr. Gray's late synopsis of the genus *Gentiana*, we find that it belongs in his first section, *Gentianella*, annuals having the corolla destitute of extended plaits, lobes or teeth at the sinuses; the anthers are versatile, and, at first, introrse, at length turning outward, with stigmas distinct. It falls into the second sub-section—flowers funnel-form, lobes entire, capsule sessile. Its characters are further limited to this subdivision, with peduncles short, terminal, or lateral; the stems distinctly wing-margined.

Further than this, the plant remains undescribed. Its nearest allies have either crowns of setæ or hairs in the throat of the corolla, or their calyx-lobes are dissimilar or are conspicuously foliaceous or spathaceous; while in this gentian there are no setæ, and the calyx is regular and very small—suggesting the specific name given of *microcalyx*.

This species grows to a height of from eight inches to two feet. The stems are quadrangular, wing-margined, branching from all the nodes in even ranks; glabrous throughout; the leaves from lanceolate to narrowly oblong, one to two inches long, the lowest shorter, all sessile and narrowed at base, three to five-nerved; calyx very small, five-cleft to the middle; the teeth lanceolate, half a line long; the tube ten-castate; flowers half an inch long, white, becoming greenish-yellow in drying; lobes four or five spreading, lanceolate one-third to one half the length of the tube, attenuate to a sobulate point; anthers large, black, exserted; filaments long, broad, and flat; capsule sessile, bursting the withering corolla; seeds numerous, small reticulated. A strikingly beautiful white gentian, that would be a valuable acquisition to our gardens and conservatories.

In the engraving the plant is shown, cut in two parts, for the convenience of the engraver; *a* is the calyx opened out; *b*, the flower displayed, calyx in position, corolla opened revealing the ovary; *c*, is ovary enlarged, showing the two flat, strap-shaped stigmas; *d*, the ovary, natural size; *e* is the stamen, with its double anther, enlarged.



A NEW GENTIAN (*Gentiana Microcalyx*).

A COLORED janitor of Philadelphia, named Joseph W. H. Cathcart, has a curious library, which may eventually prove useful to historians. For twenty-five years he has assiduously collected in scrapbooks whatever especially struck his fancy in the newspaper press, until now he has one hundred large volumes, which he regards with affectionate pride. Three of these are devoted to "China and Japan." "Incidents in the Life of Jefferson Davis" fill two volumes; "The Freedmen's Bureau" and "Slavery" claim each five volumes. One of the most interesting collections is "Poetry of the Rebellion," which contains about a thousand war songs.

* Read at a recent meeting of the California Academy of Sciences, by J. G. Lemmon.

MEXICAN CAVES WITH HUMAN REMAINS.

By EDWARD PALMER.

NEAR the western border of the State of Coahuila, Mexico, are to be found several caves in the limestone formation of the mountains. In these caves human remains were found. This section of country under consideration is commonly called the Lajona, which means overflowed. During the rainy season, which is the months of July, August, and September, the river Nazas overflows its banks and inundates the valley. Of late years cotton and corn have been cultivated. To prevent the excess of water from destroying the plants, large canals are dug round the fields and connected with the river. These canals are used for irrigating the crops. Previous to the advent of the Spaniards this section could not have been much cultivated, as the good land was overflowed at the growing season, and previous to the rains it was too dry for crops to mature before the wet season, when the overflow would destroy them.

It presents to the eye of an observer a country unfit to sustain a large permanent people without modern appliances. Its numerous mountains are dry and rocky without trees, though having a few stunty bushes and plants in the shady recesses. The valley also is as dry and barren except immediately about the receding waters. The plants naturally produced in a country of this character are the cactus, agave, yucca, mesquite, *Larrea mexicana*, and allied forms. These are either armed with thorns, or are so excessively bitter that neither wild nor domestic animals using them for food can exterminate them.

Animals are scarce; deer, two species of rabbits, skunk, badgers, ground squirrels, and rats, with snakes, lizards, birds, and fish, are limited in number, except rabbits and blackbirds.

The food products of a country determines its capacity to sustain life, especially when without domestic animals, and situated as these people were in the midst of a desert waste without any productive country immediately near from which to draw food supplies, moving from place to place as the food and water supply admitted during the dry season, in the wet they could with pack-animals move their effects to the near mountains in which water is then to be found. During the dry season there are but two plants in that section, which could be counted upon for a supply of food, game being merely incidental.

In the spring the center or crown of the agave was roasted, when it became a nutritious article of food, and in summer the mesquite beans are ripe. After the flood of waters had subsided, annual plants, like the sunflower, would produce abundance of seeds, which the inhabitants could return and gather.

As to the dead found in the caves, they had their knees drawn to their chin, also the hands, and so incased in their robes and so securely bound with bands made of network that they formed a convenient bundle for handling. Some had but one wrapping around the bones, others two; these during life were clothing and bedding, one worn round the waist and fastened by a belt; the other, worn over the shoulders, was fastened by two strings attached thereto for that purpose. Those with only one wrapper, which was worn on the shoulders by day, wore around the waist in two parts appendages made of fringe or cloth;

sometimes feathers were attached to the fringed ends to make the fringe longer and more showy; one division was worn behind the other in front. The heads of the dead were variously cared for. One had drawn over it a worked bag, another had a cap of net-work, to which was fastened a profusion of feathers; this head rested in a collar of braided cat-tail rushes; other heads were placed in round pads that are usually worn on the heads of females to support the jars of water while carrying them. Sandals of various qualities were used, made of agave fibers. The ornaments worn were seeds of plants, vertebræ of snakes, roots of medical plants, pieces of shell, bone, or stone cut into suitable shapes.

Caves as depositories of the dead were very suitable, and saved the labor of digging graves in the earth. In the caves the dead were laid therein without any earth being placed over them.

Raw materials for clothing were supplied mainly from the different agaves and yuccas; in fact, all the fabrics and sandals found with the cave dead were made from the fibers or leaves of those plants. Skins of animals seem only used to a limited extent for clothing, these plants furnishing a cooler and more durable fabric for hot climates.

The remains found in the cave have their hair done up in one bunch behind, and bound very tight by cords; they are very short in length, very unlike the hair of many of the Indians of the United States, whose hair hang down to and below their waists, done up in two bundles, one on each side, larger than the bunch found with the cave dead.

The wooden handles and tools were cut by stone tools, and when they were required to be sharp, smooth, and round, they were rendered so by rubbing with stones.

As no ruins of ancient dwellings are to be found in the cave district, it is to be inferred that they lived in dwellings of very perishable materials.

Baskets, plain and ornamented, were made from the split twigs of the rhus or split roots of the mesquite, bound over small rolls of grass. Dress goods were all made by hand-loom, or made of skins, and all garments of the same fashion were as plain as could be made. Only two pieces of pottery were found. If the warlike character of the people is to be inferred from the implements found, they should be considered very peaceable, for only two arrow-heads, parts of two bows, and one arrow shaft, to which is attached a piece of reed, having inserted in it a piece of a wooden arrow, the kind often used to kill small game; knives of fine finish, made of stones, which by their size and shape would indicate they were used in cutting the maguey plant for roasting, and for dividing it after being cooked, were found.

For beds, small sticks and twigs of plants, over which were laid grasses, leaves, hides of animals, or mats, were used, as indicated by the remnants found in the caves. For covering by night, their clothing answered admirably, being long and of a width sufficient to cover them; their garments may be called long, narrow blankets, retaining their strength to the present time; bands, parallel lines, or simple diamonds or squares were used in ornamentation. The colors used in dyeing are yet bright and perfect, being black, yellow, brown, red, and orange.

Easily constructed from the small pools, and sticks for the side and frame; for a roof, grass and earth, or yucca leaves were used. These simple huts were airy and cool, suited to the wants of a people living in a state of nature and the requirements of a hot climate.

Are the native inhabitants of the country under consideration, descendants of those whose remains are found in the caves? Though they have been modified to some extent by the Catholic religion, and introduced customs from Spain, they present very much in their customs which compel the belief that they are yet more truly Indian than anything else. They live in their simple huts with a household paraphernalia of Indians, often without the least furniture. Beds, blankets, belts, shoes, baskets, crockery, hand-looms, and metates or stone mills with which they prepare their seeds and grain for food, are still used, and the present inhabitants use many native plants and seeds for food that were used by the cave dead, while cotton and wool have taken the place of the agave and yucca fiber for clothing, and leather is substituted for plant fibers and leaves for shoes; it is only change of materials, not of mode of manufacture or superiority of workmanship that makes a difference. The fiber of the agave, though not now in use for clothing, is yet used to make ropes, mats, etc.; the mode of preparing the fiber is handed down by cave people, and the knife now used for the cutting up of the agave plant for domestic uses, though of iron, is fashioned after the stone knife found with the dead in the caves. As one sees the people in their domestic relations, in their daily vocations, when engaged in their dances, in their desire for idleness, taking into consideration all the above-mentioned traits, one comes to the conclusion that they are the descendents of the cave people. The influence of the Catholic Church has caused them to bury their dead in the ground. The present race not of Spanish origin is Indian.

Glancing over the physical geography and the natural productions of the country about the caves, the question may be asked, How high in the scale of advancement did the former inhabitants of this section rise? The clothing and utensils found with the dead answer the question. A race of Indians, without commerce, dependent upon the natural productions of a desert country to supply their daily want; long practice in the use of their simple arts had created that perfection which has given rise to the belief that only a superior race could produce like results. A people in nature, in a climate with nine months drought, without domestic animals and modern civilization, could not become rich or civilized according to modern views. Studying closely this section, with the evidences found with the cave dead, and comparing other lands with a similar production, one finds there a like race, with corresponding manners and customs. Take for instance ancient Peru and its people; the Territories of Arizona, New Mexico, and Southern California with their inhabitants as found at the Spanish Conquest, and compare them with that portion of Mexico formerly inhabited by the race whose remains are found in the caves, and one will find not only a resemblance of productions from the soil, but the people possessing the same ability to take nature's gifts, and adapt them to their every day wants in a highly satisfactory manner. We are astounded in beholding their workmanship; they simply took nature's gifts and made the best of them. Comparing the cave clothing with that of the ancient Peruvians, we find a close alliance; both made by a hand-loom, the same as is used by the Indians of Peru, Mexico, Arizona, New Mexico, and Southern California to-day. The rude Navajo Indian makes a blanket upon one of these hand-looms, which commands not only a good price from white men, but their admiration—yet he is considered a savage—lives in a hut. It is not necessary to live in palaces, in order to perform great works, and it is shown by our ancient and modern American Indians, that they were equal to emergencies, until compelled to face Europeans with their civilization.

In the New and Old World, it is customary to consider those that lived in caves to be a distinctive people from those called Pueblos or town-dwellers. The evidences of these kinds of habitations are to be found in many places. There was another class of dwellings: the perishable huts made of tree branches and thatched, of which nothing is left. The dwellers in each of these three classes of buildings might be of the same race. In the winter living in caves, in summer or while attending to crops they might live in temporary stick huts. Some caves contain human remains: these have been put there as the easiest means of disposing of the dead. If surrounded by enemies, as the industrious and peaceful Indians of ancient times were, they had become Pueblos or dwellers in towns as a means of defense; yet they could be of the same people as the cave-dwellers, or those who inhabited brush-houses. There was a distinctive race from the above which lived in brush huts; they lived by the chase, and roamed at will over the land, always warring against the town-dwellers. In some sections many stone implements are found, in others those of bronze. The finding of these tools of different materials is no evidence of their being made by distinctive people or in remote periods from each other, for sometimes one finds both together. Ancient and modern people in nature use whatever their section afforded. There is no reason to suppose that the so called mound-builders were different from the cave-dwellers. Town-dwellers, makers of flint or bronze implements, they were all of the same great division, *i. e.*, buriers of the dead. Their war-like enemies compelled them to live in brush huts, built together in a wooded country in winter, and in the openings in summer; thus the mounds with human remains therein occur in these sections.

A difference in the kind of dwellings or tools do not of themselves warrant the conclusion of some writers that each distinctive class was an evidence of tribal or race difference. We might as well consider the makers of pottery a distinct people; but they were not, for every race of Indian made and used pottery in ancient times, and at the present time, even the warlike Indian, without fixed habitation, has his, though of a plainer kind. There are some who think that the kind of pottery argues a different race origin; this is not so, the different qualities of pottery and forms are designed to suit the different purposes for which they were made, and not for a display of race distinctions. In Mexico and the United States, in ancient times, the Indians used the same method of rendering their pottery hard and smooth as is now practiced by the Indians of Mexico to-day. A pebble of agate or jasper is used to rub over the surface of the pottery as soon as the new made article is dry; a fine, hard, smooth surface is the result; it has been considered a varnish. I saw it in general use; it is a new fact not known to writers before my visit to Mexico in 1877 and 1878.

In conclusion, I would say that there are two races of Indians to-day, as there were in ancient times, circumstances causing various interminglings, resulting in differences in manners and customs.—*American Naturalist.*

ON THE CONSERVATION OF SOLAR ENERGY.

By DR. W. B. CARPENTER.

THE meeting of the Royal Society, on March 2, was rendered unusually interesting, first, by the admission of H.R.H. the Prince of Wales, as a Fellow of the Society; second, by a communication given by Prof. Huxley on the fungous origin of the "Salmon Disease," which is destroying large numbers of fish in the rivers of the south of Scotland and the north of England, from the Tay to the Conway; and last, but by no means least, by the exposition given by Dr. Siemens of an "idea" regarding the mode of maintenance of the solar energy, which he has been for some time maturing, and has at last determined to submit to the criticism of the scientific world. Of this most ingenious and suggestive speculation, the following sketch will, I hope, prove as interesting to the readers of *Knowledge*, as Dr. Siemens' own admirable and more detailed statement of it was to the members of the large scientific gathering to which it was addressed.

In the first place, he reminded us of the enormous amount of heat which is constantly radiating from the sun into space; this, according to the best measurements that have been made, being such as would be maintained for only thirty-six hours by the complete combustion (as in the most perfectly constructed furnace) of a mass of the best coal equal to the earth in bulk. Now, if the sun were surrounded by a solid sphere of a radius equal to the mean distance of the earth, the whole of this heat would be intercepted by it; but since the diameter of the earth, as seen from the sun, is only seventeen seconds, so that its surface is only 1-2,250,000,000th part of the whole area of such a sphere, only that proportion of the entire heat radiated from the sun will fall upon the earth. Supposing the aggregate of all the planetary bodies to intercept ten times as much as the earth, the total amount of solar heat thus utilized will be only one part in 225,000,000 of the total radiated from the sun; the other 224,999,999 parts to all appearance going to waste—in other words, doing no work.

Now the mode in which this enormous supply is kept up has been in all ages a question of great interest; but only in modern times could any scientific solution of it be even attempted. Of course, chemical action would be the first source that would occur to almost every one—radiation of heat from a fire being the nearest thing within our experience to the heating effect of the solar beams. But, putting aside other difficulties arising out of the revelations of the spectroscope, the ordinary chemical hypothesis is met by the objection that the acumulation of the products of combustion on the surface of the sun would in time form a barrier against further action. And, supposing this barrier disposed of, it is obvious that the maintenance of this combustion must be attended with a continual *wasting away* of the sun, at a rate which would make itself perceptible in the disturbance of planetary equilibrium, when the loss is estimated for long periods of time.

An opposite idea was suggested some years ago by Sir William Thomson: that of a continual rain of meteorites upon the sun—the velocity they would acquire from its attraction causing them to impinge upon its surface with such force as to generate a large amount of heat when their motion is checked. But here we are met by two difficulties: first, that of conceiving of any supply of meteorites that would be competent thus to keep up the amount of heat which we know to be always radiating from the sun; and secondly, the progressive *increase* in the bulk of the sun that would be produced by any adequate supply disturbing the planetary equilibrium in the contrary sense to the preceding.

It has been supposed by Helmholtz, and accepted by many physicists on his authority, that the radiant energy of the sun is the result of a progressive *shrinkage* of his bulk and condensation of his substance. But the giving out from his surface of the heat thus generated in his interior could only be accomplished through some medium of much greater conductivity than is possessed by any material known to us; and on this process, again, a limit is obviously imposed, since a time would come when (as seems now the case with the moon, and nearly so with the earth, Venus, and Mars) the limit of consolidation would be reached.

Dr. Siemens, as every one knows, is the inventor of the regenerative furnace now coming into general use; in which a large proportion of the heat that ordinarily goes up the furnace-chimney and runs to waste is recovered from the products of combustion, carried back into the furnace, and made to do its proper work—thus obtaining an enormous advantage in economy of fuel. Mentally projecting this terrestrial experience into the realms of space, he was led to the conviction "that the prodigious and seemingly wanton dissipation of solar heat is unnecessary to satisfy accepted principles regarding the conservation of energy; but that it may be arrested and returned over and over again to the sun, in a manner somewhat analogous to the action of the heat-recuperator in the regenerative gas-furnace." The fundamental conditions of his hypothesis are three.

I. Every one who has followed the recent progress of celestial physics is aware of the increasing reasons which there are for regarding not only plenetary but stellar space as occupied by *matter* in a very attenuated condition; and Dr. Siemens starts with the assumption that this matter chiefly consists of hydrogen, oxygen, nitrogen, carbon, and their compounds (especially aqueous vapor and carbonic acid), besides solid material in the form of dust. The existence of oxygen, nitrogen, and carbon he considers to be indicated by the presence of those elements in our own atmosphere, to which (according to the molecular theory of gases) no such limit as was formerly assigned to it can now be admitted. We get a clew to the gaseous components of what may be called the "atmosphere of space" from analysis of the gases locked-up in freshly-fallen meteorites, which sometimes "occlude" six times their own bulk. A recent analysis by Dr. Flight gave nearly 46 per cent. of the total as consisting of hydrogen, 32 per cent. of carbonic oxide, and 18 per cent. of nitrogen; and it seems clear that the hydrogen and carbonic oxide could not have been absorbed during the passage of the meteorite through our own atmosphere, but must have been brought in from the outside. Further proof that stellar space is filled with gaseous matter is furnished by spectrum-analysis; and the recent investigations of Dr. Huggins and others into the composition of the last great comet showed it to contain very much the same gases with those contained in meteorites.

II. It was long since shown by Sir William Grove that water can be decomposed—or, in modern chemical language, that oxygen and hydrogen can be "dissociated"—by heat alone; and we know that the dissociation of the oxygen and carbon in carbonic acid is effected by light acting through certain vegetable substances. Now, according to the law of dissociation developed by Bunsen and Saint-Clare Deville, the point of dissociation of different compounds depends upon temperature on the one hand and pressure on the other; so that it is quite conceivable that when aqueous vapor is reduced to extreme tenuity, its dissociation may be effected by solar radiation at a comparatively low temperature. Some years ago Dr. Siemens tried some experiments on this point, the results of which were (so far as they went) confirmatory of this view. And his recent well-known experiments on the growth of plants under the electric light have satisfied him that, provided the source of the light give it off in sufficient *intensity*, the *quantity* required is very small. And he is thus led to suggest that all the radiant energy which is seemingly running to waste, is really doing work in dissociating the aqueous vapor and carbonic acid of the "space atmosphere," the carbon being thus made ready to unite with the nascent hydrogen into combustible hydrocarbons.

III. The third basis of Dr. Siemens' doctrine is the effect that will be produced by the rotation of the sun around its axis on the distribution of gases and vapors in its atmosphere. The tangential velocity of the sun at its equator being nearly four times that of our earth, an extension of the solar atmosphere must take place in the equatorial plane, to which (reviving an old hypothesis, and explaining away the objection raised to it by Laplace) Dr. Siemens attributes the "zodiacal light." Pressures being balanced all round, Dr. Siemens shows that the sun would be continually drawing hydrogen, hydrocarbons, and oxygen from the "space atmosphere" toward its polar surfaces, and be continually projecting outward the products of their reunion from the equatorial extension of its own atmosphere. During their gradual approach, they will pass from their condition of extreme attenuation and extreme cold to that of compression, accompanied with rise of temperature, until, on approaching the photosphere, they burst into flame, giving rise to a great development of heat, and themselves acquiring a temperature proportionate to the pressure they are sustaining. The result of their combustion will be aqueous vapor and carbonic oxide or carbonic acid, according to the sufficiency or insufficiency of the oxygen present to complete the combustion; and these products of combustion, yielding to the influence of centrifugal force, will flow toward the solar equator, and be thence projected into space.

In this manner a continual interchange of matter will be taking place between the sun and its "environment;" and as the sun is constantly and rapidly moving through space, it will be continually traversing new portions of the "space-atmosphere," which, it is conceivable, may be so differently charged with the supplies of material as to be more or less potent in maintaining the solar energy.

Such is a general outline of Dr. Siemens' most ingenious speculation, which, whatever may be its ultimate issue, must be accounted one of the highest and most brilliant flights that the "scientific imagination" has ever made. Such as desire a more detailed exposition of it—especially as to the changes which Dr. Siemens supposes to be always taking place on the surface of the sun itself—will find it in his paper, which will speedily appear in the "Proceedings of the Royal Society." Its publication will doubtless give rise to much discussion; and, whatever may be the ultimate fate of the doctrine as a physical theory, there can be no doubt that in the new direction which it will give to investigation, its promulgation will contribute in no small measure to the advance of science.—*Knowledge.*

THE TIMBER LINE.

By HENRY GANNETT.

IN Dr. Rothrock's valuable report on botany, recently published by the "Surveys West of the 100th Meridian," the author quotes Dr. Engelmann's statement that "there is little or no increase in altitude in the timber line toward the equator, in our western hemisphere, south of the 41st parallel of north latitude."

This statement is approximately true regarding the Rocky Mountains, owing, however, not to any general principle, but to what may be termed an accident of topography. Even here a decided rise is observable from 41° to 30° of latitude. In the Sierra Nevada, the Basin and Wahsatch Ranges, the statement does not hold good, the timber line rising rapidly as the latitude decreases. Again, on the volcanic peaks of the Mexican plateau, the timber line is higher by several thousands of feet than it is anywhere in the United States.

Barring the prohibitive circumstances of absence of soil and moisture, the height of the timber line is purely a question of temperature. The latter is a function of the latitude, the elevation, and the mass of the country in the neighborhood. A great mass of country, if raised to a considerable height above the sea, as in the case of the great Cordilleran plateau of the West, carries up with it, to a certain extent, the isothermals. A glance at Mr. Schott's admirable isothermal charts amply illustrates this general fact. Washington, D. C., has a mean annual temperature of 55° Fah., while Denver, Col., a fraction of a degree further north, and at an elevation of 5,300 feet, has a mean temperature, not of 37°, as the height might indicate, but of 49°.

Therefore, in considering the height of the timber line, we must regard the mountain ranges in connection with the plateaus upon which they stand, their latitudes, heights, and masses, or what, in a measure, sums up these three, their temperatures, as it is by these that its height is determined.

Looking at the subject from this point of view, a fair comparison may be instituted between the timber line in different latitudes and on different ranges in the same latitude.

The actual elevation above sea level of the timber line in the Cordilleras of North America ranges from 6 or 7,000 to 12,000 feet. It is lowest in the Coast and Cascade Ranges of Washington Territory, where it is at about the former figures. Following the Cascade Range southward into Oregon, the timber line rises to a height of 7,000 to 8,000 feet. It continues to increase as we trace it southward into California, being on Shasta and the neighboring mountains 8,000 feet above the sea. On the high sierras of Eastern Central California, forests grow to 10,000 or 11,000 feet, while the San Bernardino and other ranges of Southern California do not reach the upper limit of forests.

Few of the ranges of Nevada reach the timber line, which is at a height of 9,000 feet in the north up to probably 11,000 feet in the southern part of the State.

In Arizona, probably none of the mountains reach the timber line, except the volcanic group known as the San Francisco Mountains and the Sierra Blanca. On these the timber line is between 11,000 and 12,000 feet.

In New Mexico it averages about 12,000 feet above sea level. There is little variation between the northern and southern parts of the territory, as the higher annual temperature of the southern part is fully compensated for by the greater altitude of the plateau in the northern part.

In Colorado, it ranges from 12,000 feet in the southern part to 11,000 in the north. It is highest in the great mass of the San Juan Mountains and in the Sangre de Cristo range, and lowest in the northern portions of the Park and Front Ranges.

In Southern Wyoming, in the Park Range, which is the only one in this portion of the territory which rises above the limit of timber, this limit is at about 11,000 feet. In the Wind River and Téton Ranges, in the northwestern part of the territory, it is at an elevation of 10,000 to 11,000 feet.

In Montana and Idaho, the limit of timber is, in general, from 9,000 to 10,000 feet, being highest in the south, and lowest near the northern boundary.

In the Uinta and Wahsatch Ranges of Utah, it is about 11,000 feet, rising somewhat above this figure in the southern part of the latter range.

Thus it is seen that in the same latitude there is a very marked difference in the height of the timber line. The less the elevation of the surrounding country, other things being equal, the lower is the limit of timber.

This suggests a further point. The upper limit of timber must have approximately the same mean annual temperature everywhere. Of course it will differ to a slight extent in different localities, owing to difference of exposure to wind and sun, but these are mere local circumstances, not affecting the general principle. The determination of this temperature accurately is, without direct observation, of course, impossible. I have, however, computed it approximately from such data as are available, and have found tolerably close accordance among the results.

The mean annual temperature decreases about 1° Fah. for each 300 feet of abrupt ascent. In the case of Pike's Peak and Colorado Springs, where the difference of elevation is more than 8,000 feet, the change is 1° for each 295 feet. In the case of Mt. Washington and Shelburne, New Hampshire, it is 325 feet for each degree. The former case is the most favorable in every respect, and as most of our results are drawn from the western region, I have adopted, as a round number, 300 feet.

Now, if the average mean annual temperature all around the base of a mountain were known, it would be a very simple matter to determine, with some accuracy, the temperature at timber line, knowing its height and the mean height of its base. The nearest approach which can be made to this, is to assume that the station or stations at or near the base represent the average climate, a supposition which, in many cases, is by no means correct. Using, however, in the manner indicated, such data as are at hand, I have obtained the following results:

Mountains, etc.	Height of timber line, feet.	BASE STATION.			Temperature at timber line.
		Name.	Height in feet.	Mean an. temp.	
Cunningham Pass, Colo.	11,500	Fort Garland	7,945	43°	31°
Mt. Lincoln, Colo.	12,051	Fairplay	9,965	38°	31°
Mt. Silverheels, Colo.	11,549	"	9,965	38°	33°
Mt. Guyot, Colo.	11,811	"	9,965	38°	32°
Mt. Powell, Colo	11,600	White River Agency	6,491	45°	28°
Pike's Peak, Colo.	11,720	Colorado Springs	6,032	48°	29°
Gray's Peak, Colo.	11,100	Denver	5,244	48°	29°
Wahsatch Mts., Utah	10,000	Salt Lake City	4,350	52°	33°
Mt. Washington, N. H.	4,150	Shelburne, N. H.	700	42°	30°
Mt. Marcy, N. Y	4,851	Somerville, N. Y.	412	45°	30°
" "	4,851	Plattsburg, N. Y.	180	44°	29°
Mt. Blackmore, Mont.	9,550	Fort Ellis, Mont.	4,935	44°	29°
Mt. Bridger, Mont.	9,002	" "	4,935	44°	31°
Mt. Delano, Mont.	8,784	" "	4,935	44°	31°

The mean of these results is 30·4°, and this is probably very near the true mean annual temperature of the timber line. The better the conditions of the determination, the nearer are the results to this mean. Mts. Blackmore and Bridger are very good cases, being on the border of the Gallatin Valley, in which Fort Ellis is situated, and but very few miles distant from the latter. Mts. Lincoln and Silverheels are also admirably situated with respect to Fairplay, but the annual temperature of the latter station is not well determined. Pike's Peak and Colorado Springs make an excellent pair of stations, being but ten miles apart, and the annual temperature at the latter place being well determined by the observations of the Signal Bureau. On the other hand, Mt. Powell and the White River Agency are widely separated by many miles of high plateaus, which may materially change the conditions of the temperature about the mountain.

Should this result, when tested by a wider range of observations, hold good, it will afford a very valuable and easily obtainable isothermal, and also enable one to estimate the height of the timber line from thermometric stations at the bases of mountain ranges.—*American Journal of Science.*

IRONWOOD TREE.

ONE of the hardest woods in existence is that of the desert ironwood tree, which grows in the dry wastes along the line of the Southern Pacific Railroad. Its specific gravity is nearly the same as that of lignumvitæ, and it has a black heart so hard, when well seasoned, that it will turn the edge of an ax and can scarcely be cut by a well-tempered saw. In burning it gives out an intense heat.

CONSTITUENCY OF WOOD.

ALL woods heated away from the air yield watery vapor chiefly, leaving nearly pure charcoal, which, when burned, leaves more or less mineral matter as ashes. Of green wood from one-third to one-half or more of its weight is water, the conditions partly depending upon the time of cutting. A gentleman made experiments on a basis of 100 pounds, and found they contained water as follows:

	Cut in Jan.	Cut in April.
Ash, pounds water	29	38
Sycamore	33	40
White pine	52	61

All kinds of wood cut in January contain from 15 to 25 per cent. less water than after the sap is in motion in April, and considerably earlier in the Southern States. As wood seasons naturally in the air, it loses from one-sixth to one-third its weight of water, but still contains from one-seventh to one-fourth its weight of moisture. A considerable part of the latter may be expelled by kiln-drying, and most of it if the kiln heat be raised to 212°. Some careful tests made showed that five cords of beech and maple just cut weighed as much as eight cords of the same wood when thoroughly air-seasoned. This teaches us a practical lesson: that is to haul and handle green wood requires a very large waste of strength. In handling five cords of green beech wood, for example, we have loaded, hauled, and unloaded three or more tons of useless water, which a few months' seasoning would have removed. A cord of wood contains 128 cubic feet as it lies piled up. But allowing for the interstices in fairly piled wood, we may reckon a cord to actually contain about seventy-two cubic feet of solid wood. Thoroughly dry wood weighs about as follows, per cubic foot and cord:

	One cubic foot.	One cord.
Hickory, pounds	62	4,464
White oak	53	3,816
White ash	49	3,528
Red oak	45½	3,276
White beech	45	2,240
Apple tree	43	3,096
Black birch	43	3,096
Black walnut	42½	3,060
Hard maple	40	2,880
Soft maple	37	2,664
Wild cherry	37	2,664
White elm	30½	2,628
Butternut	35½	2,556
Red cedar	35	2,520
Yellow pine	34	2,447
White birch	33	2,376
Chestnut	32	2,304
White pine	26	1,872

If the wood is to be used for steam-generating purposes, the relative values per cord, of various seasoned woods, taking into account weights, heating power, etc., and valuing hickory, as a basis, at $5 per cord, we reach the following results:

Hickory	$5.00
White oak	4.05
White ash	3.85
Apple	3.50
Red oak	4.45
White beech	3.25
Black walnut	3.25
Black birch	3.15
Hard maple	3.00
White elm	2.90
Red cedar	2.08
Wild cherry	2.75
Soft maple	2.70
Yellow pine	2.70
Chestnut	2.60
Butternut	2.55
White birch	2.40
White pine	2.10

We find no record of careful experiments to test the relative value of cottonwood and rosewood or linden. The hickory named above is what is known as the shellbark hickory (*Carya alba*). The pignut hickory (*Carya porcina*) is of nearly equal value. The western hickory (*Carya sulcata*) weighs about 25 per cent. less than the shellbark, and its relative value per cord is estimated at $4.05, or the same as white oak.—*N. W. Lumberman.*

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